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DISCOVERY

A MONTHLY POPULAR JOURNAL OF KNOWLEDGE

EDITED BY A. S. RUSSELL, M.C., D.Sc.

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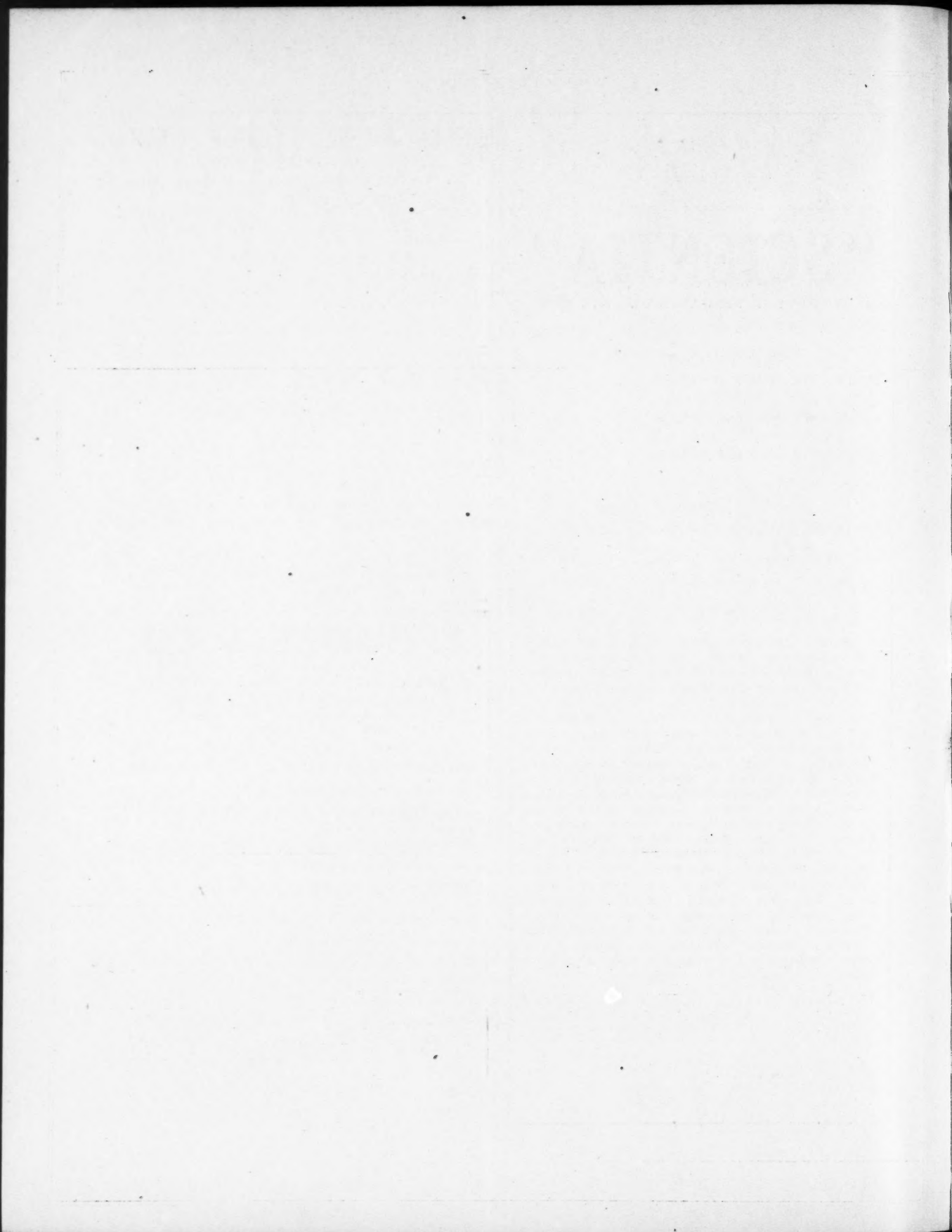
ROCK DWELLINGS IN CAPPADOCIA
Village of Matchan

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JOHN MURRAY, 50A ALBEMARLE STREET, LONDON, W.1.





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DISCOVERY. A Monthly Popular Journal of Knowledge.

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Editorial Notes

THE Managing Committee of DISCOVERY regret to announce that, through the pressure of his work at Oxford, Dr. A. S. Russell will be obliged to relinquish the Editorship in the near future, though he has kindly consented to continue to act as Scientific Adviser. The Committee is well assured that it represents the feeling of many thousands of readers in offering Dr. Russell its cordial thanks for the invaluable service he has rendered to the journal in its first and most critical year; and in expressing great satisfaction that he will continue his help in securing articles on scientific subjects and advising the editor on any questions connected with them.

* * * * *

The April number of the *Psychic Research Quarterly* has interested me very much, and makes me feel the sorrier that it is shortly to be turned into a larger and more ambitious periodical called *Psyche*, which intends to review the whole field of psychological inquiry. Such a periodical no doubt will meet a growing need, but the problems and difficulties of psychical research might

have been more conveniently discussed in a smaller periodical devoted exclusively to it.

* * * * *

In the April number is a curious article by the Rev. C. Drayton Thomas on Book and Newspaper Tests. Tests of this kind are a comparatively recent development in Psychical Research, and are considered to be among the most interesting and important phenomena at present under investigation. In a book-test the "spirit" through the medium sends a message in which part of the message is connected with a word or a sentence on a certain page of a book. This stands in a certain part of the house, and was known to the "spirit" when he was alive but is unknown either to the medium or to the person for whom the message is intended. For example, the message which the medium receives from the "spirit" deals with a great controversy in the Press, and gives a reference to the middle of p. 54 of a certain book standing, say, third from the left end in a certain book-case in a certain room. Later, after the séance, in the middle of p. 54 of the very work cited by the "spirit" occurs the sentence—

"... when the hour for combat strikes and the decision ..."

And there you are: Strikes—Strike—Coal-strike—Great Controversy in the Press!

* * * * *

In Mr. Thomas's experiments the information he received periodically through the mouth of the medium was verified (or he believed it to be verified) in *The Times* of the day after the séance. On a first reading of his article it all appeared to me to be rather wonderful, but a rereading made me much less convinced. There seems to be no reason to look for any abnormal explanation for these phenomena. Gullibility, chance, coincidence, an occasional good guess, the ability of a certain type of mind to put two and two together and make it (within limits) into almost any number, and a few similar explanations, seem to me to account for them all. Mr. Drayton Thomas very wisely always sent the

notes predicting the event to a disinterested person on the day before *The Times*, which confirmed the event, came out, so that one obvious explanation of the matter is excluded.

* * * * *

Here is, from his notes, one message received from the medium:

"In column one and about a quarter down is your father's name given in connection with a place he knew very well about twenty years ago"; and here is Mr. Thomas's comment upon it:

"Between a quarter and a half-way down is the name 'John' and one inch above it is 'Birkdale.' My father's name was John, and 'Birkdale' is the name of the house he bought when retiring from active work and where he resided until his death."

This is a typical example from Mr. Thomas's article. At first it struck me as so ingenuous that I suspected the author of pulling my leg. But no. He is serious. Come, now, is there anything wonderful about the name John (not Hieronimus or Jared or Septimus Eric, but John) appearing in any column of *The Times*? It would be more wonderful, surely, if it failed to appear less than ten times. Again, there is nothing wonderful in the apparent fulfilment of the prophecy concerning Birkdale. Notice, Birkdale is not mentioned specifically by the medium. It is merely a particular example of a general category, places which a man knew twenty years ago. Now, in 1901 I was only a small boy, but the number of places I knew "very well" then was anything from a hundred to a thousand, depending upon what is meant by a place. The probability that the name of one of these should appear in a column of *The Times* is a very great one. These book-tests, indeed, are rubbish. There is absolutely "nothing in them." Mr. Drayton Thomas does not appear to understand coincidence and correlation.

* * * * *

In the same magazine is an interesting and informed article by two authors on Spirit-photographs which deserves to be read widely. The conclusion of the authors is that most spirit-photographs appear to be fakes; but the most interesting part of the article lies in the description of the numerous methods by which a photographer who wants to deceive may do so. Many of these depend upon co-operation between the photographer and an accomplice, some merely on sleight-of-hand, some simply on knowing your audience, and some on certain scientific facts known to the deceiver but unsuspected by his clients.

* * * * *

Who would imagine that it is possible for a photograph of a suitable object to be taken in a perfectly

dark room by a plate that has been carefully wrapped up and sealed and never previously exposed? Yet anyone who has persevered in the science of physics as far as the standard required for London Intermediate knows there are rays invisible to the eye which can penetrate with ease several layers of paper and affect the plate (or film) photographically. In such a case wrapping up the plates and sealing them, as spirit-photographers love to do, is analogous in simplicity to shutting and sealing up the gate of a field on a windy day to keep out the draught!

* * * * *

A camera may record a good deal more than meets the eye. Invisible stars, for example, may be detected by the photographic plate. A can of hot water may be photographed, by a long exposure, in a perfectly dark room. A well-known instance of a similar phenomenon is Sir Robert Ball's story of the writing on the side of the "Great Eastern" which was successfully photographed a great many years after it had been painted out and rendered invisible. The reader may also be referred to the article on radiography in the present number. The man who wants to believe in spirit-photographs is inclined to believe, or is led to believe, that anything he cannot explain must be due in some way to "spirits." Naturally he cannot be expected to be a walking encyclopædia of the sciences, and so he falls an easy victim to deception.

* * * * *

No amount of argument along these lines avails with some people. Many people are happier in being cranks than in looking facts in the face. Others feel that the denial of "spiritualistic" manifestations is to abandon everything, and to leave only a purely materialistic and sordid world of muscle and sex, of muck and misery. But the higher things in life—religion, idealism, the belief in a spiritual order of things—have absolutely nothing to do with table-rapping, spirit-photography, and so forth. These manifestations can be explained by natural causes, known or unknown, and by the "human touch" (which in many cases is imposture).

* * * * *

The views of Mr. Vincent Patrick (one of the joint-authors of the article referred to) on the so-called "Fairy Photographs" recently published by Sir Arthur Conan Doyle and Mr. E. L. Gardner are very interesting. He considers all this talk about the physical existence of fairies to be bunkum, and the photographs to be fakes. It will be remembered that Sir Arthur Conan Doyle said of the latter that such "rare results must be obtained when and how they can." A cynic might well remark of this that its speaker is not merely looking for

trouble, but actually inviting it to assault him. Mr. Patrick, however, very wisely ignores the motives of those who are trying to popularise a belief in fairies, and relies for his evidence of fraud on the published photographs themselves. They look very genuine and the fake is very cleverly done. But fakes they are. In one entitled "Iris and the Dancing Gnome," he finds from the shadows that the strongest light is falling on Iris from the *right*, while the gnome is lighted mainly from the *left*. This is not possible. There is clear evidence also that the photograph is too artistically beautiful to be the *snapshot* it professes to be. The gnome's proportions are not human. Probably he has been sketched on to a positive enlargement from the negative of Iris, and the whole then rephotographed on to a quarter-plate.

In other photographs, "Alice and the Fairies" and "Alice and the Leaping Fairy," the fairies appear to be human in proportions. They show a sharpness of outline which the human figure in the photograph lacks, also they are illuminated from behind while the human figure is illuminated from the side. Probably children suitably dressed have been photographed. The background has been cut out (hence the sharpness of outline), and the photos of the children have been pasted on to an enlargement of that of the human figure, and the whole rephotographed. Thus it seems to be.

There are several interesting articles in a little book entitled *The Fight Against Disease* (Macmillan, 6d.) issued by the Research Defence Society. One refers to the advances recently made towards the discovery of a *protective* treatment against tuberculosis, such as at present exists against typhoid. Dr. Calmette has been working on the Protection of Cattle from Tuberculosis at the Pasteur Institute. His work is founded, of course, on Pasteur's discovery of the attenuation of virus; the gradual bringing-down, point by point, of the virulence of the germs of a disease, by growing them, in pure culture, in test-tubes, under certain conditions which have a lowering effect on them: growing them, through a long series of such cultures, in successive test-tubes, from generation to generation, and then using them, thus weakened, to protect animals against the disease at its natural strength. By this discovery, Pasteur was enabled, in 1881, to protect animals against anthrax.

Calmette has discovered how to attenuate the germs of bovine tuberculosis, by growing them in pure culture, through many generations, on a special medium of glycerine and bile. By this discovery, he has been enabled to protect animals against the disease at its natural strength. One of his experiments may be

described here. He took ten heifers, proved free of tuberculosis. He kept four of them as "controls," without any treatment; he treated six with a protective dose of germs attenuated through seventy generations of pure culture. All ten heifers were then stalled in the company of cattle which were tuberculous. This experiment was kept up for more than three years. Then the heifers were tested with tuberculin. The six protected animals came out free of the disease: but three of the four controls had acquired it.

His work is bound to move slowly, but those who know his value, and his high place in the scientific world, have reason to think well of this new research.

The article concludes: "Some day, we shall have in our hands the inestimable gift of a protective treatment for our own children against the germs of human tuberculosis. Take, for example, the case of a family in which there is a strong tendency to consumption. Imagine it possible, by a protective treatment, to be able to help the children to tide over the susceptible years; imagine them enabled to put up more of a fight against adverse conditions. It seems already put in our hands."

Is there a professor of Dactylography anywhere? A bi-monthly magazine with this subject for its title is to appear on the 1st of July. It will deal chiefly with the evidence for criminal and other identifications by means of finger-prints; but attention will be given also to a study of the detective aspects of foot-prints—including boot-prints—tattoo marks, deformities, and the like. Consideration will also be given to such evidence as is usually called for from police experts regarding the minute texture of paper and other fabrics; the microscopical, chemical, and biological qualities of blood smears; poisons; evidence from wounds; attitudes and condition of the dead; the nature of the weapons used, and so on. It is intended to make this journal quite intelligible and useful to all who have to do with the detection and judicial investigation of crime.

Man and His Past,¹ by Mr. O. G. S. Crawford, a noted archæologist and geographer, is a book I have enjoyed reading. It has a freshness about it, a breadth and an optimism which one views with pleasure in a book dealing with anthropology and archæology. The main theme of the book is the need for the study of man's past, because of the demonstrably great but often overlooked importance of the past upon our present. It is cordially recommended to readers, especially to those interested in history.

¹ Oxford University Press, 10s. 6d.

Robin Hood: the Man and the Myth

By E. L. Guilford, M.A.

Sherwood in the twilight, is Robin Hood awake?
Grey and ghostly shadows are gliding through the brake;
Shadows of the dappled deer, dreaming of the morn,
Dreaming of a shadowy man that winds a shadowy horn.

Robin Hood is here again: all his merry thieves
Hear a ghostly bugle-note shivering through the leaves,
Calling as he used to call, faint and far away,
In Sherwood, in Sherwood, about the break of day.

IN his fine poem from which these opening lines are quoted Alfred Noyes has seized on the spirit of Sherwood Forest—the Sherwood Forest of Robin Hood—as no other poet has done since the ballad-writers set down their songs on paper. To every healthy-minded boy Sherwood Forest and Robin Hood are one, inseparable and for ever associated in one of the finest tales of adventure that we have.

We have nearly all a joyful recollection of the pleasure we derived from reading the adventures of Robin Hood, Little John, Friar Tuck, Will Scarlet and the rest, and even to this day, when the critical spirit of maturity has ousted the omnivorous receptiveness of boyhood, I love to read again the pranks played by this band of joyful sinners on the representatives of authority. Many a time, when wandering in the glades of the Forest, I have fancied that the spirit of Robin Hood still haunts the shadows and that the old trees, stately in their glorious antiquity, nod their sage heads as they tell once more of the deeds they saw when they were young. The exploits of Robin Hood cannot be read by anyone without some stirring of the pulse, for surely no popular hero has ever possessed so much *joie de vivre*; he was certainly a cheerful sinner, and most people have in their hearts a soft place for all such.

The modern historical spirit is a critical one. It refuses to accept as a fact anything which cannot be proved by documentary or other irrefutable evidence. All the heroes of our childhood's history must pass through the test, and few, alas, escape unscathed. The passing of these cherished stories into the limbo of legendary history may be a gain to the pure historian, but it is a loss to the spirit of the nation, for in them is embodied much that true history never records, but which is none the less true in spirit if not in fact. No one has suffered more than Robin Hood in this respect. We are told that King Alfred never proved himself a hopeless failure as a baker, that Canute did not challenge the waves to wet his royal feet, and that Hengist and Horsa are symbols and no more; but

Robin Hood is being taken from us and placed in the realm of fiction.

It is my object in these lines to try to show how much about Robin Hood we really can discover, and if we must regretfully admit that he was a medieval counterpart of Mrs. Gamp's Mrs. Harris and that there was no such person, let us at least try to save some fragments from the rubbish-heap of history.

Robin Hood was probably the most popular hero of the medieval ballad-maker, and Mr. F. J. Child, in his monumental collection of English and Scottish ballads, has preserved nearly fifty distinct songs about him. These are really our only source of information, and if we would find anything out about him, we must seek for it within these ballads.

The earliest recorded mention of the existence of these ballads occurs about 1377 in *Piers Plowman*, where the poet refers to "Rhymes of Robyn Hood and Randolf erle of Chestre," and the earliest ballad that has come down to us appears to have been set down during the first quarter of the fourteenth century. Until recent times no one doubted that Robin Hood was a real person, and it was only when a search was made for facts about his career that it was discovered that no authentic mention of him occurs anywhere. He is merely a ballad hero and no more. Persevering seekers have unearthed at least a dozen Robert Hoods from the dusty files of official documents and have tried to fit them into the vacant niche, but none of them are acceptable, for they do not seem to be the kind of men who could even in their youth have lived the life of a chivalrous and cheerful sinner. These men have each their champions who have tried to place them definitely in the reign of Richard I, Henry III, or Edward II. But the evidence is unconvincing, and it is better that these bearers of a famous name should return to their obscurity than that we should seek to spoil the romance of Robin's life by bringing him to end it as a servant of the King, living on a pension because he was too decrepit to do his work.

On the other hand, as opposed to the school who seek to fix a date for his death we have those who try to convince us that in the story of Robin Hood we have a sun myth; but personally we are inclined to seek for an approximation to the truth somewhere in between, and perhaps the best way to approach the subject is to see what the name Hood will teach us.

In the first place it is a common name and is found in use long before the Norman Conquest, and, what is more, it is employed in a suggestive way twice in two very different parts of the country. In an Anglo-Saxon charter relating to Worcestershire we have Hod's Oak, and in Nottinghamshire, within the bounds of Sherwood Forest, there is the village of Hodsock, which means the same and was in existence at the time when the

Domesday Book was compiled. Now, of course, the letter "h" is, and always has been, a very elusive letter, and it is quite possible that Robin Hood and Robin o' th' Wood are synonymous. That such a change is possible is shown by the certified fact of such an actual alteration taking place. In the early eighteenth century a gipsy family named Wood went to live in Wales, and to-day their descendants are called Hood. Once we discover that "Hood" and "Wood" are not entirely strangers to one another we remember that there was once a heathen god called Woden, but really the somewhat ponderous behaviour of Woden does not seem to tally with the pranks played by Robin Hood, and I would rather see in Robin o' th' Wood, Robin Goodfellow, better known as Puck; but this is pure imagination, and has no firmer base than is here indicated.

Though the ballads firmly attach Robin Hood to Sherwood Forest, yet there is evidence that perhaps his original home must be sought farther north. In Cumberland we find three ballad heroes, Adam Bel, Clym of the Cloughe, and Wyllyam of Cloudele, whose exploits, though far fewer in number, are the exact counterparts of those of Robin Hood, with the substitution of Carlisle for Nottingham and Inglewood for Sherwood.¹ One of the ballads makes three men contemporaries of Robin Hood's father, who, if we may credit the ballad, was an even greater archer than his son:

The father of Robin a forrester was,
And he shot in a lusty strong bow,
Two north country miles and an inch at a shot,
As the Pinder of Wakefield does know.

For he brought Adam Bell, and Clim of the Clough,
And William of Clowdesle,
To shoot with our forrester for forty mark,
And the forrester beat them all three.

His mother was neece to the Coventry knight,
Which Warwickshire men call Sir Guy;
For he slew the blue bore that hangs at the gate,
Or mine host of the bull tells a lie.

In the earliest ballads that have come down to us we find that Robin has, like William of Cloudele, two companions, Little John and Mutch, the miller's son. These are the only ones mentioned by name, though there were a considerable number of others in the band.

Robyn take a full grete horne,
And loude he gan blowe;
Seven score of wyght yonge men
Came redy on a rowe.

It is only in quite late ballads that any attempt was made to identify Robin with an Earl of Huntingdon; in all the early ones he is simply a yeoman:

¹ Also William of Cloudele performs the apple-shooting feat of William Tell.

Roben Hood was the yeomans name,
That was boyt corteys and fre;
For the loffe of owr ladey,
All wemen werschep he.

Robin Hood's first meeting with Little John is the subject of one of the later ballads:

When Robin Hood was about twenty years old,
He happen'd to meet Little John,
A jolly brisk blade, right fit for the trade,
For he was a lusty young man.

Tho' he was called Little, his limbs they were large,
And his stature was seven foot high,
Where-ever he came, they quak'd at his name,
For soon he would make them to fly.

Another of the band who plays but a small part is mentioned as being with Robin at this time—Will Stutely, but how he came to join the party is not related.

But I can hear my reader asking why no reference has yet been made to Friar Tuck and Maid Marian. The reason is that neither of these well-known and picturesque characters plays an important part, indeed it is only in the later songs that they appear. Scholars tell us that Maid Marian is imported into the Robin Hood cycle from France, and certainly no mention of her occurs before 1500. Friar Tuck, or the curtal friar of Fountains Abbey, is the subject of a late ballad where, like Little John and others, he gets the better of Robin Hood and is accordingly made a member of the band.

And coming unto Fountaine Dale,
No farther would he ride;
There he was aware of the curtal fryer
Walking by the water side.

The fryer had on a harnesse good,
On his head a cap of steel,
Broad sword and buckler by his side,
And they became him weele.

Friar Tuck is a curious ecclesiastic: a friar who is a member of a Cistercian community and occupying a distant cell of the mother house, and yet going about armed to the teeth. He is certainly very untrue to life, and seems to be a late creation of an inaccurate age.

In the ballad of Robin Hood and Maid Marian we find that, according to the true tradition of ballad-mongers, Robin is the Earl of Huntingdon and Marian is a "country lass." They fall in love, then part and, like Shakespeare's Rosalind, Marian disguises herself:

Perplexed and vexed, and troubled in mind,
She drest herself like a page,
And ranged the wood, to find Robin Hood
The bravest of men in that age.

For some unstated reason Robin is also disguised. They meet but do not recognise each other, and as

always happens when Robin meets a stranger they fight and wound each other. Of course all ends happily.

In solid content together they liv'd,
With all their yeomen gay ;
They liv'd by their hands, without any lands,
And so they did many a day.

Now there is a point about all the Robin Hood cycle of ballads which strikes us and leads us to a fresh aspect of the whole matter. Whenever the time of the year is mentioned it is always summer, and generally early too. The earliest ballad of all opens with :

In somer when the shawes be sheyne
And leves be large and longe,
Hit is full mery in feyre foreste
To hear the foulis song.

If we study the characters who took part in the May games, we find that Robin Hood and Maid Marian appear and are representatives of the Hobby Horse and May Queen respectively. Probably the popularity of these two brought them in, but we find in parts of England a curious Christmas custom known as the "Hoodening Horse." A roughly-carved horse's head was carried round and a collection of money made. What is the meaning behind these facts? Is there any connection between the part played by Robin Hood and the Hoodening Horse, and can we see in the latter a survival of a very old reverence for the horse as typifying the spirit of the corn, which had to be pacified in order that the year's crops might be good? We are getting out of the realms of history—if we have ever been in them—beyond romance, and are trespassing in the treacherous morasses of folk-lore. But the more we seek to find the origin of Robin Hood, the more are we attracted down seductive bypaths, and as we return more puzzled than before, we realise that though we are no nearer a satisfactory solution, yet we feel we are studying a subject which may at any moment reveal to us a vast unconquered world.

Probably the ballad-monger thought it only fitting that his hero should die, and so a story was invented of his visit to his cousin at "Kirkley-hall" and her treachery in bleeding him. When he realises that he is dying, Robin blows his horn and calls Little John to his side, and his directions to him are well worth quoting :

But give me my bent bow in my hand,
And a broad arrow I'll let flee ;
And where this arrow is taken up,
There shall my grave digg'd be.

Lay me a green sod under my head,
And another at my feet ;
And lay my bent bow by my side,
Which was my music sweet,
And make my grave of gravel and green,
Which is most right and meet.

Let me have length and breadth enough,
With under my head a green sod ;
That they may say, when I am dead,
Here lies bold Robin Hood.

So it was that in the seventeenth century it was thought fitting that a tomb at Kirklees Nunnery should be ascribed to our hero and that his epitaph should be placed on record. A later writer, early in the eighteenth century, supplies us with a fresh inscription and the actual date of his death—November 18, 1247.

What, then, can we gather from all this medley of fact and fiction about Robin Hood? If he had an actual living prototype, we must go back very far, so far that no historical record remains. Once he had become the hero of the ballad-singer Robin made rapid advances, and yet most of the additions which we can definitely state to be of later origin are of a stereotyped form. Robin's deeds are not peculiar to him, and the characters who gather round him are part of the stock in trade of the professional ballad-singer. If we could get the ballads in their earliest form we might learn more, but that, unfortunately, is impossible and we must leave Robin with the fitting words of his own chronicler :

Thes partyd Robyn, the screffe, and the potter,
Ondernethe the grenewood tre ;
God haffe mersey on Robyn Hodys solle,
And saffe all god yemanrey !

The Radiography of Pictures¹

How the Forger of Spurious
"Masterpieces" can be defeated
by the X Rays

By George Frederic Lees

"Do our readers know that there exists in Paris a manufactory in which artists, receiving large salaries, copy the canvases of the Great Masters? These pictures are sent to the United States, a high duty is paid upon them, and, being thus stamped as authentic, they are then sold for their weight in gold to American millionaires. In the gallery of one of these collectors can be seen quite a number of pictures the originals of which are either in Paris or in the provinces."

Writing, many years ago, in the *North American Review* on the subject of the traffic in spurious pictures, I had occasion to quote the above paragraph from a

¹ Illustrated with Photographs and Radiographs by Dr. André Chéron, of Paris.

Paris morning newspaper. The production of forged "masterpieces" bearing the names of Van Ostade, Ruysdael, Hobbema, Raphael, Boucher, Watteau, Corot, Diaz, Théodore Rousseau, Ziem, and other eminent painters of ancient and modern times was then most intense. Not merely one manufactory, as the paragraphist seemed to think, but quite a number of studios where picture forgers worked existed in the Montmartre and Montparnasse quarters, without counting those which were in the suburbs and provinces. Whereas in previous years these copyists, *pasticheurs*, and painter-restorers—each working at his own speciality—could be counted on the fingers of both hands, they had become a veritable army in the days to which I refer, and, though armed but with brushes and colours, the havoc and confusion they wrought was great indeed. Connoisseurs all over the world have still to be on their guard against the clever productions of these picture "fakers"; and so numerous are spurious canvases signed with great names, due not only to these unscrupulous forgers but to their predecessors and successors, that there is probably not a single public or private picture gallery which does not contain their handiwork.

Arrested during the period of the Great War, the lucrative trade in spurious pictures has been resumed and is now once more in full swing. Painters, painter-restorers, and others with a talent for this particular branch of fraud are hard at work in secret, employing the same old methods that were in vogue during the nineteenth century, but applying them to the production of works bearing the names of artists, both ancient and modern, who have come into their own of recent years. The contest between the picture forger and his prospective victim, the connoisseur, being eternal, it will be well, before describing a means by which many forgeries can be unerringly detected, to understand the various tricks resorted to by the fraternity of picture "fakers."

It is useful to know, for instance, that when, some thirty to forty years ago, pictures by Masters of the 1830 school came into favour, all the canvases by pupils of Corot, Diaz, Troyon, Rousseau and others were collected and re-signed. That is the reason, an expert assures me, why there are so few pictures by Villers and Mazon to be found. These excellent painters produced many works, but because of the greater renown of Millet and Corot, it was their fate to be absorbed, as it were; their paintings are hanging at this very moment in the galleries of great collectors, but baptised with other names than those of the men who painted them! One wonders if their signatures were entirely removed or merely covered up, in which case it is now possible, as will later be shown, to bring them to view.

About the year 1880, genuine pictures by Corot, Daubigny, Diaz, and Théodore Rousseau used to be copied by the clever hirelings of certain Parisian art-dealers. In one instance, the copyist, working at a house in the country, alone with a single servant, made twenty-five copies of each picture, slightly varying the subject in each case. He produced one hundred copies in ten months, and all of these, as leaked out later through indiscretions, were sold in the United States as originals from the collections of this or that well-known Parisian. To detect the hand of the forger in such a case as this, presuming that he is really an expert worker, is extremely difficult, if not impossible; one must look for evidence of the fraud in other quarters.

Infinite precautions are now taken by reputable art-dealers who represent great modern painters to protect the artists' interests, those of the heirs, and their own pockets against possible fraud. Every work produced is carefully photographed and catalogued. On the death of a celebrated artist, a photographic reproduction is made of every work, study, or sketch in his studio, so that when these are dispersed they will be in possession of a weapon against the picture forger who may be tempted to acquire an unfinished landscape and complete it after the manner of the Master. It is when the copyist, aided by the painter-restorer, comes to work on old canvases that he is liable to be unmasked. The *modus operandi* in this particular branch of "faking" is as follows:

A dealer collects together a number of pictures by one or other of the Old Masters whose works are not in vogue—if possible pictures by a painter who worked somewhat in the style of this or that celebrated artist; and from these, by means of skilful retouching, works are produced which eventually bear the magic names of Rembrandt, Raphael, Teniers, Corregio, and others. In the case of portraits and pictures containing figures, such as those by Largillière, a similar method is adopted, only care is taken to select canvases the light parts of which are uninjured and as near as possible in the style of the Master whose work is to be imitated. With the assistance of good engravings, the drawing is slightly altered; half-tones and shadows are added; and, by means of glazes, the necessary piquancy and effect are produced. Naturally, canvases of the correct period, and genuine old stretchers—or panels, in the case of painters who usually painted on wood—are selected. Such works by Old Masters who are not in vogue and are never likely to be, except as material out of which "masterpieces" are made—such old stretchers and panels are often on sale at the Hôtel Drouot, the great sale-rooms in the street of that name in Paris. Many people unacquainted with the work of the picture forger wonder how it is such "rubbish" finds eager purchasers.

The patina and cracks of old pictures are what give the most trouble to those who use this ancient trick.

Some picture forgers use saffron, bister, liquorice,* or black coffee, which have now replaced bacon rind, so much used in former years. When this has been applied and is quite dry, the picture is varnished. Sometimes thick oil is added to the varnish, or it is coloured with bitumen, yellow lac and red ochre, which give almost exactly the tone of old varnish.

Up to recent years the only way of frustrating the dishonest picture-dealer and his accomplice, the copyist or painter-restorer, was to have recourse to expert opinion. Long study of the undoubtedly authentic works of the Great Masters enabled such experts and art-critics as Paillet, Regnault, Delalande, Duclos, Thore Burger, Philippe Burty, and Eugène Piot to

Schneider Sale, in 1876, two Rembrandts were sold as doubtful; that in 1899 a Nattier, belonging to the collection of Mme Richard, née Bournet Aubertot, was sold for 49,500 francs, despite the fact that many well-known judges present at the sale declared it to be a forgery; that at the Guasco Sale, in 1900, a Troyon was falsely described as having been in the collection of the painter and bore a forged stamp of the Troyon Sale; and that at the Rey Sale, in the same year, a so-called Raphael was sold as a genuine work, the description in the catalogue being inaccurate as far as that particular work was concerned—it applied to quite another (genuine) work. But this system of keeping track of the innumerable forgeries which are in circulation, satisfactory though it was in a great number of cases, naturally broke down at times. Forgers of exceptional



FIG. 2.
RADIOGRAPH OF THE "CRUCIFIXION"
BY ENGELBRECHTSZ.



FIG. 1.
THE "CRUCIFIXION" BY ENGEL-
BRECHTSZ. THE PICTURE BEFORE
RESTORATION.



FIG. 3.
THE "CRUCIFIXION" BY ENGEL-
BRECHTSZ. IN ITS PRESENT STATE
AFTER RESTORATION.

pronounce accurate judgment, at any rate in a large majority of cases, whenever the authorship of pictures was in dispute. Thus picture buyers were put on their guard, especially when the science of the art-critic was supported by those who made it their business to record the multitudinous instances in which spurious pictures were declared to be forgeries. Connoisseurs were able, thanks to special advice and annotated catalogues, to avoid falling into the traps which were perpetually being laid for them by unscrupulous dealers. They were aware, for instance, that in 1868, on the occasion of the sale of the collection of His Excellency Khalif-Bey, two Fromentins were declared at the sale to be mere copies; that in the following year, at the Besborodko Sale, several pictures, including one Albert Cuyp and a Rembrandt, were likewise denounced; that at the

Schneider Sale, in 1876, two Rembrandts were sold as doubtful; that in 1899 a Nattier, belonging to the collection of Mme Richard, née Bournet Aubertot, was sold for 49,500 francs, despite the fact that many well-known judges present at the sale declared it to be a forgery; that at the Guasco Sale, in 1900, a Troyon was falsely described as having been in the collection of the painter and bore a forged stamp of the Troyon Sale; and that at the Rey Sale, in the same year, a so-called Raphael was sold as a genuine work, the description in the catalogue being inaccurate as far as that particular work was concerned—it applied to quite another (genuine) work. But this system of keeping track of the innumerable forgeries which are in circulation, satisfactory though it was in a great number of cases, naturally broke down at times. Forgers of exceptional

skill have succeeded in deceiving the most erudite critics, hence the conflict of opinion which has often arisen, as in the dispute in London some years ago over an alleged Romney, in art circles. Manifestly a more infallible method of examining the *facture* of a given painting was required; and to find it a number of scientists set their wits to work, with most interesting results.

Professor A. P. Laurie, of Edinburgh, called in the aid of the microscope to distinguish the characteristic brush-work of the Great Masters, and thereby discovered that the methods of applying the paint had changed but little since the days of antiquity. Artists living at the time of the Roman Emperors painted with large and small brushes on canvas, which they prepared with a basis of oil, gum, and glue, afterwards varnished.

The drying of their pictures, however, presented difficulties, owing to ignorance of the difference between pure oil and siccative linseed oil; and to remedy this the galipot method was then adopted—that is to say, colours were first of all ground with turpentine and then, when in the form of powder, diluted with a varnish composed of the said galipot (white resin, a sort of turpentine) and spirits of turpentine. This technique changed but little down the Ages, bringing Professor Laurie to the conclusion that as regards the instruments of their art there was practically no change from the days of Leonardo da Vinci to those of Renoir and the

one to six diameters; whereupon it became evident that, in the fight against the picture-forgers, photography and its various applications was to play one of the most important of rôles.

To H. Parenty, of Lille, is due the credit for having discovered that by simple photography it was possible to penetrate the undeniable transparency of the layers of paint on pictures, and thus reconstitute, as it were, certain details in the works of Titian, Rembrandt, Rubens, and other Great Masters that are invisible to the naked eye. This at once led other technologists to ask themselves the question, Why not employ X rays?



FIG. 4.
"VIERGE DE STELLA."



FIG. 5.
RADIOGRAPH OF THE "VIERGE DE STELLA" SHOWING
DAMAGED PORTION WHICH HAS BEEN RESTORED.
In the centre a bar of wood prevented complete passage of the X rays.

Impressionists. However, the pigments used in painting *did* vary considerably from period to period, and by applying his method to a large number of works of absolutely certain date, the investigator with the microscope was able to draw up a chronological list of pigments of the greatest utility. Microscopic study of the pigments of a given painting enabled one, then, in many cases, to determine its date approximately and to declare whether any portions had been retouched by restorers. Advancing this excellent method one more step further, Professor Laurie took micro-photographs of minute portions of ancient canvases, enlarged from

No sooner said than done. And thus, in 1914, the first researches concerning the radiography of pictures were made in Germany by Faber, as related in the *Zeitschrift für Museumkunde*. Dr. Heilbron, of Amsterdam, continued them with most curious results. Finally, between the middle of 1920 and the present date, we find a Parisian specialist, Dr. André Chéron, perfecting the method to such a degree that we are tempted to say the days of the picture forger are numbered.

Dr. Heilbron's results must first of all be described. As the subject for his investigations he took a "Crucifixion," by Engelbrechtsz, a picture which was

suspected of having been tampered with. It was noticed that the figure of a nun in the foreground on the right was not in harmony with the other personages (Fig. 1), and as the canvas had been presented to a

to X rays depends on the number and weight of the atoms of which they are formed. Now, in the case of a picture, there are three things to be considered: the support (canvas or panel of wood), the priming with which this support is covered, and finally the colours composing the picture.

"The support is always very transparent, but canvas much more than wood.

"As regards the priming, it appears to result from the documents we possess on the subject of the making of colours and the preparing of canvases and panels that the old painters primed their supports with a mixture of carbonate of lime and glue, which is relatively transparent to X rays. At the present day, on the contrary, painters use, almost exclusively, a priming of white lead, which is much more opaque.

"As to the colours used by the artist to compose his subject, they are also of atomic weight, and consequently of a most variable transparency to the rays. Some, such as white, are and have always been almost exclusively composed of heavy salts, of lead or of zinc; therefore they are a serious obstacle to the passage of the rays. Others, such as bitumen and most of the blacks, are extremely light and allow the rays to pass



FIG. 6.
"ROYAL CHILD AT PRAYER."
Fifteenth-century picture in the Louvre.

certain religious establishment by a nun, it was thought to be more than likely that this kneeling praying lady with white cap and rosary was a portrait of the donor, added by a painter who came long after Engelbrechtsz. Dr. Heilbron radiographed the "Crucifixion," with the result predicted: beneath the clumsy addition was the original figure, that of a praying monk, in perfect harmony with the rest of the picture (Fig. 2). Apart from this revelation, radiography served the useful purpose of showing the artist's own brush-work before restoration and enabled this work, which unfortunately, as is the case with all very ancient pictures, had become indispensable, to be more skilfully restored to its present state, as shown by Fig. 3.

Working in accordance with the indications given by Faber and Heilbron, and guided by his own great experience as a radiographer, Dr. André Chéron—to whom, let me say in passing, I am indebted for the illustrations accompanying these lines—has considerably advanced the science of the radiography of pictures. Here, in a few words, is the principle of his method; I quote from his communication presented to the Academy of Sciences, at Paris, by Dr. Lippmann, at the sitting of January 3, 1921:

"We know that the degree of transparency of bodies



FIG. 7.
RADIOGRAPH OF "ROYAL CHILD
AT PRAYER."
Showing damaged background.

through very easily. Finally, between these two extremes, we find a whole series of intermediaries.

"But a certain number of colours which were formerly

made from mineral salts are now sometimes formed from vegetable substances much more transparent, e.g. madder. The same applies to certain modern colours with an aniline base.

"Now, it is very evident that, in order to obtain a good radiographic image of a picture, two things are essential:

"1. The transparency of the support and the priming.

"2. The relative opacity of the colours or at least of certain of the colours employed in the contrasts forming the image.

"Precisely these conditions are found united in ancient pictures. On the other hand, modern pictures provided with a somewhat opaque priming covered with colours often more transparent to the rays give much less perfect images, which are often even almost invisible."

Dr. Chéron, whilst hesitating to draw hasty conclusions from his researches, went on to say that one might, therefore, sometimes hope to discover through radiography the age of a picture and consequently reveal its authenticity. Another result, thanks to X rays, was the power to show all the damage a work of art has undergone down the ages, notwithstanding the most skilful restoration. In fact, as ancient pictures are in question, the priming and colours used for restoration would be of a different manufacture and probably of a different atomic weight, and would be reproduced on the plate by veritable spots with a perfectly definite shape, revealing ravages sometimes unsuspected.

"Finally—and this is perhaps the most interesting side of these researches," continues the Doctor, "picture radiography reserved very many surprises. To see a picture by transparence is to know its history in part. Apart from the fact that the artist himself may have modified his work whilst painting it, the portions 'faked' or repainted, the additions made to it are revealed to us; without mentioning the various unexpected discoveries of entire pictures under works of later date."

I have reason to believe that when Dr. Chéron wrote these last words he had in mind the statement that, at the time when David and the painters of the Classical School were at the height of their popularity, some of the canvases of Fragonard were regarded as of such little artistic value that the artists of that School used them for the production of their own works. What a prospect, indeed, the radiography of pictures opens up for us in that direction!

We will now turn our attention to the pictorial demonstration of Dr. Chéron's researches—a most convincing demonstration if ever there was one.

Figs. 4 and 5 display very clearly the contrast between the radiograph of an ancient picture and the picture itself. The "Vierge de Stella" has clearly-

defined outlines and the figures can be recognised. On the other hand, it reveals, at the bottom of the picture, restoration the extent of which was unsuspected. In a modern picture, on the contrary, no image would be visible, apart from those parts which alone are formed of a colour sufficiently opaque to make a shadow through the white lead priming covering the canvas.

Figs. 6 and 7 are of special interest, since this picture of a "Royal Child at Prayer," belonging to the French School of the fifteenth century, is in the Musée du Louvre, where it was only recently radiographed. The Curators of the gallery believed, in accordance with statements made in certain documents, that the original background of the picture was at some time or other greatly damaged, and that about a century ago the damages were masked by means of the uniform black background now seen in the picture. This hypothesis is wholly confirmed by the radiograph. Moreover, it shows that the painter at first made the child's bow a little too large and then corrected his error.

Many photographs show how easy it is to unmask the picture forger by means of radiography. One of the pictures radiographed represented a little Flemish scene with country folk dancing and playing musical instruments. The radiograph was most curious, for there was not a trace of figures (apart from the head of one of them, faintly visible in the centre), but in their place appeared two peacocks, two ducks, and two hens with very clear outlines. Evidently the picture was really two pictures, one over the other on the same support, in this case a wood panel. The first picture, that of the birds, was an ancient work, since there was no opaque priming to destroy the clearness of the outlines; the second—falsely attributed to Van Ostade—was probably modern, since the colours, with the exception of the whites, were almost uniformly transparent to the rays.

It should be said, in conclusion, that these results have produced a profound impression in Parisian art circles. M. Jean Guiffrey, the Curator of the Louvre, finds them "most interesting." The well-known critic M. Charles Henry says: "There can be no doubt that this method of examination is capable of furnishing experts with new and precious elements" to enable them to form an opinion. Whilst that excellent publication *Le Bulletin de la Vie Artistique* pronounces the scientific value of Dr. Chéron's work as undeniable. Henceforth it ought to be impossible for any more spurious "masterpieces" either to come into sale-rooms or pass the Customs at the port of New York.

Bibliotheca Chemico-Mathematica. A catalogue of works in many tongues on exact and applied science. Two vols. (Henry Sotheran & Co., 63s.)

To be reviewed next month.

Rock Dwellings in Cappadocia

By W. R. Halliday, B.A., B.Litt.

Professor of Ancient History in the University of Liverpool

THE soft volcanic tufa of many parts of the Eastern Mediterranean has given a long life to the primitive practice of cave-dwelling. In the Cyclades, notably in Santorini (Thera), the houses are often little more than façades built on to hollows in the rocks, and the back rooms are in fact caves. For this casual practice of cave-dwelling convenience may no doubt account and the desire to expend as little trouble as necessity demands. Further East, however, in Asia Minor, a less fortuitous troglodytic existence has been deliberately

food. There were stores within of wheat and barley and vegetables, and wine made from barley in great bowls." Of this beer Xenophon adds that it is very potent and "of a delicious flavour to certain palates, but the taste must be acquired."¹

A good deal to the west of Xenophon's line of march, in the Cappadocian Plain between the southern bend of the River Halys and the Taurus Mountains, very similar burrows can be visited to-day. The present villages above ground are composed of miserable houses built of sun-dried brick and plastered with dung. In summer the latter commodity, which is also dried to serve as fuel cakes in a country of cold winters but destitute of trees, somewhat obtrusively pervades the air. In winter the snow lies deep on this plateau five thousand feet above the sea. In severe weather the animals are all taken indoors as Xenophon saw them in



FIG. 1.—VILLAGE OF AXO, SHOWING SUN-DRIED BRICKS AND FUEL CAKES.

adopted and whole settlements have been excavated underground. Here the motive seems more probably to have been the desire for security in a troubled land.

When Xenophon and the Ten Thousand were fighting their adventurous way to the sea after the Battle of Cunaxa had stranded them masterless and friendless in the heart of hostile Asia, they encountered upon the borders of Armenia a people who lived in underground burrows. "The houses were underground structures with an aperture like the mouth of a well by which to enter, but they were broad and spacious below. The entrance for the beasts of burden was dug out, but the human occupants descended by a ladder. In these dwellings were to be found goats and sheep and cattle and cocks and hens with their various progeny. The flocks and herds were all reared under cover upon green

December 401 B.C. Over a brazier a large felt rug is spread, and round it the members of the patriarchal household recline with their lower extremities beneath the rug. Thus through the worst of the winter man and beast hibernate together in an atmosphere which, if warm, must possess other less pleasant qualities.

Beneath these villages, which are inhabited for the most part by a Christian Greek-speaking population, there lies a rabbit warren of subterranean dwellings, and in them the inhabitants may formerly have lived. Local tradition at Misti, a large village of 800 households, which lies on the high road from Nigde to Kaisarieh, assigns a recent date to the emergence of its population from these burrows, and it is improbable

¹ Xenophon, *Anabasis*, iv. 5 (trans. Dakyns).

that the houses have existed above ground much longer than the church, which was built in 1844.

The entrances to the subterranean dwellings are in every case inside private houses. Your host takes you into his back premises, which extend themselves into an aperture like an enlarged rabbit-hole down which it is necessary to crawl upon hands and knees until the entry proper to the settlement is reached. This is marked by a recess at the side of the passage in which there is a mill-stone. From an inner chamber this stone can be rolled into position, completely blocking the passage; only the central hole of the mill-stone remains, and through this a rifle can be fired. "From inside we used to shoot with a gun thorough the hole in the mill-stone and shoot the Turks," said a modern

villages, we were told, had taken refuge underground at the time of the Adana massacres. I can only hope that their cities of refuge may have enabled some of these Christians to survive the Great War. For with a sufficient supply of food they should be impregnable, except to blasting operations, for an indefinite period.

Not less interesting are two series of rock-cut dwellings above ground. The material of the Cappadocian plateau appears to consist of a very soft volcanic tufa with a thin protecting layer of harder rock on top. At two places there are cracks in this covering, and in these valleys the soft rock thus exposed has shown itself equally plastic to the agency of nature and the hand of man. One of them I have not had the good fortune to visit; the other, which runs from two masses

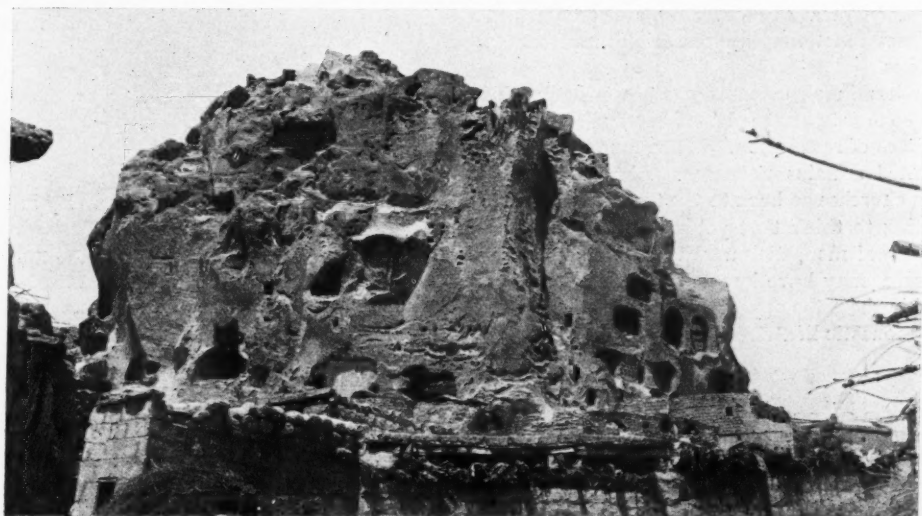


FIG. 2.—ROCK DWELLINGS, UTCH HISSAR.

informant, and in the Middle Ages a captain of Timour Beg, who was sent to hunt out the cave-dwellers of this district, was shot with an arrow in similar fashion.

Beyond the mill-stone is a series of dwelling-rooms, churches, and store-houses (that below Misti is reputed to contain as many as 400 dwellings), and the whole honeycomb is grouped round the village well, which in this waterless area is often very deep. Suvermes, "water is lacking," the Turkish name of one of these villages, tells its own tale, and at another, Malakopí, the level of the water is about seventy metres below the ground. The burrowed habitations are also carried to a considerable depth. At Malakopí there are no less than five series one below the other and each defended by a mill-stone door.

These subterranean warrens are called *καταφύγια*, "places of refuge," and the greater part of one of the

of rock called Utch Hissar, "Three Castles," by the village of Matchan, the ancient Matiane, is the most remarkable natural spectacle I have seen. The rocks at Utch Hissar, thrown up perhaps by some volcanic agency, were honeycombed at some date unknown by human inhabitants. Weathering has now stripped the outer surface of the rock, and the oblong niches to be seen in Fig. 2 are rooms the outer walls of which have dropped away.

But more remarkable still is the valley at the head of which these masses of rock are placed. Here the absence of the hard integument has left the soft stone bare and nature has weathered it into a series of fantastic cones. Looking down the valley, one sees them not in tens but in hundreds. To add to the bizarre effect, their colour no less than their shape is unreal. Some are yellowish-white, some pink, some black, and some a dirty red. It is not unlike the mountain scenery in one of Giotto's

frescoes come surprisingly to life, but yet more fantastic and strange.

The shapes, it will be seen, are chiefly conical, and in some cases where a fragment of the hard surface has survived, a "hatted" type has resulted, a block reposing on the pinnacle of the cone. Except for the rocks at Utch Hissar, none of their summits, though they may be eighty feet or more above their base, rise above the level of the valley's sides, and clearly they have been formed by erosion.

In these strange rocks the hand of man has carved fantastic dwellings and sanctuaries, and of the former some are still in use to-day. A feature of the more ambitious houses which struck me as interesting was the occasional imitation in carving of the architectural features of a true building. Thus doorposts, lintels, or arches which in a cave-dwelling are ornamental merely and not functional, are sometimes represented on the façades.

The churches in some cases contain paintings of interest, and one or two have yielded dates, though only, I believe, dates of restoration. When first these rocks were inhabited remains unknown. Almost certainly some of the churches go back to the tenth century A.D. It is tempting to think that yet earlier St. Basil, the great founder of monasticism, whose home was near by at Cæsarea, may have known of these valleys and have found in them the opportunity for developing the communal monastic life.¹

Books Received

Continuous Wave Wireless Telegraphy. By W. H. ECCLES, D.Sc., F.R.S. (The Wireless Press, 10s. 6d.)

The first part of a reasoned exposition of the science in simple form by an acknowledged authority. The fundamental principles of electro-magnetism are set forth in a manner immediately applicable to the study of Wireless Telegraphy. The physical properties of the ionic tube receive fundamental treatment. For students.

Map-Reading. By G. H. C. Dale. With a Preface by Lt.-Col. E. M. Jack, D.S.O., R.E. (Macmillan, 7s. 6d.)

A practical manual of map-reading. The subject is dealt with clearly and very simply. The problems are

¹ A description of the underground dwellings below Cappadocian villages is given in Dawkins, *Modern Greek in Asia Minor*. Mr. Childs, in *Across Asia Minor on Foot*, has described his visit to the neighbourhood of Utch Hissar. The churches of this region have been studied by French scholars. I have not seen *Eglises Souterraines de Cappadoce*, by the learned archæologist Father G. de Jerphanion, S.J., of the Université Saint Joseph, Beyrout. The first instalment of this definitive publication of their researches was due to appear in 1913.

approached from the practical point of view. Recommended to the general reader.

The English Novel in the Time of Shakespeare. By J. J. JUSSERAND. Translated from the French by ELIZABETH LEE. (T. Fisher Unwin, 4s. 6d.)

A book published some years ago which can be recommended to all lovers of the Elizabethan epoch. Like all M. Jusserand's books (he is the Ambassador of France at Washington), it is scholarly, brilliant, and entertaining.

Tidal Power. By A. M. A. STRUBEN, A.M.I.E.E. (Sir Isaac Pitman, 2s. 6d.)
One of Pitman's Technical Primers.

Primitive Society. By E. S. HARTLAND, LL.D., F.S.A. (Methuen, 6s.)

A short work on anthropology in which the idea is developed that in the early stages of advance the mother was taken as the root of family life, and the power and position of the father were gradually developed at her expense.

Bernadotte and Napoleon, 1799-1810. By SIR PLUNKET BARTON. (John Murray, 21s.)

A fully documented description of the life of General Bernadotte under the Consulate and under the First Empire down to 1810 when he was elected Prince Royal of Sweden.

Electrical Engineering. By DR. T. F. WALL. (Methuen, 21s.)

A complete survey of the principles of electrical engineering by a lecturer in Sheffield University. It is intended for students in Universities, the advanced classes of Technical Schools, and as a book of reference for engineers.

Colour Photography

By R. A. Houstoun, D.Sc., Ph.D.

Lecturer in Physical Optics in the University of Glasgow

PRACTICAL methods of colour photography are based upon the theory of primary colours, and it is no use attempting to understand colour photography without first making a determined effort to master this theory. It can, however, be promised that the subject is not a difficult one, and that the properties of the primary colours and their mixtures form one of the most fascinating studies imaginable, equally interesting to photographers, artists, physicists, and the lay public.

At the outset we must emphasise and underline the fact, that mixing or adding together two coloured lights

does not produce the same result as mixing or adding together coloured pigments, of the same colours as the lights.

Coloured Lights.—Let us suppose we have a white screen in a darkened room, and that by means of three lanterns we are able to throw three spots of light upon this screen. We can, for example, imagine we are in a theatre or music-hall, and that the three lanterns are situated in the front of the dress circle, each provided with its own operator, that the screen is on the stage, and that all lights are extinguished so that the theatre is perfectly dark. It is, of course, not necessary for the success of the experiment that it should be performed on this ambitious scale, but the description is probably easier to understand when the experiment is performed in this way, instead of by one of the methods used in the laboratory. We shall suppose that one of the spots or discs of light on the otherwise dark screen is coloured red, another green, and the third blue. Then by tilting their lanterns the operators can make these discs move across the screen and superimpose on one another. Usually the coloured light in theatres is produced by holding a sheet of coloured gelatine in front of the lantern, but the coloured gelatine employed in theatres is unsuitable for our experiment. The colours are not nearly saturated enough, i.e. not intense nor pure enough. Even the best green that the operator throws upon the villain contains a good deal of white in it. The red required for our experiment must be a pure red without any tint of orange, somewhat similar to the red of the railway signal lamps; the green must contain neither yellow nor blue, and must be purer than the green of the signal lamps; the blue must be an ultramarine with a good deal of violet in it.

Under these circumstances, if the red is superimposed on the green we obtain yellow. Strong red imposed on weak green gives orange, weak red on strong green yellowish-green. Green superimposed on blue gives peacock blue. Red superimposed on blue gives magenta, and red on a stronger blue gives purple. Red, green, and blue superimposed on one another make white. If white is dimmed, we get grey; if orange is dimmed, we get brown. Superimposing white on any colour makes it paler. Thus by means of the three colours red, green, and blue we obtain nearly all the colours that occur in nature. They don't give us violet, but pure violets do not occur frequently in nature. So red, green, and blue are termed the three primary colours. Putting our results in the form of a table we obtain:

Red + Green + Blue = White	
Red + Green = Yellow	}
Green + Blue = Peacock Blue	
Blue + Red = Magenta	

Red + Peacock Blue = White	}
Green + Magenta = White	
Blue + Yellow = White	

Peacock blue, magenta, and yellow are termed the three complementaries, since each of them combined with one of the primaries gives white. Peacock blue is sometimes referred to as minus-red, since it is the colour obtained by subtracting red from white, and in the same way magenta and yellow are referred to as minus-green and minus-blue.

Coloured Pigments.—We have now to consider the mixture of coloured pigments. We are all to a certain extent familiar with this subject owing to our experience with water-colour paint-boxes when children; we then learned that yellow and blue make green, a result which does not agree with those set forth in the table above. Whence comes the contradiction?

A red object—for example, a stick of red sealing wax—appears red because, when the three constituents of white light—namely, red, green, and blue—fall on it green and blue are absorbed, and red alone is reflected; in the same way a green object appears green, because it absorbs the red and blue constituents of white light, and only the green constituent is reflected. If a red and a green paint are mixed, the mixture should therefore absorb all three constituents of white light, red, blue, and green, and consequently appear black, instead of yellow, as we would obtain on mixing red and green lights. A mixture of pigments gives only the colour which neither absorbs, not the sum of the two colours, as we obtain when adding lights.

This can be illustrated very prettily by means of the three complementaries, yellow, peacock blue, and magenta. Stained gelatine film can be obtained from Kodak, Ltd., Kingsway, London, E.C., exactly the colour of the complementaries, and when these films are combined two and two together, they give the colours of the primaries with very great accuracy. It is difficult to get paints or inks giving the colours of the complementaries exactly right, but three of Dove's waterproof inks, the yellow, the Prussian blue, and the carmine, are fair approximations. Small bottles of these inks can be obtained in most shops that supply draughtsman's materials. They are brighter and purer than the corresponding colours of the water-colour paint-box. The effect of mixing these colours can be studied best if they are added with a brush to a little water in the bottom of an egg-cup. If the carmine, which absorbs only green, is added to the yellow, which absorbs only blue, the mixture is red. If the yellow, which absorbs only blue, is added to the Prussian blue, the mixture is green. If a little carmine is added to the Prussian blue, we get an ultramarine blue similar to the third primary, and if we add more carmine we

obtain purple; but the results are not so good in this case, as the Prussian blue is not a peacock blue and absorbs some green.

It is the three complementaries, yellow, magenta, and peacock blue, that are used in three-colour printing, as may be seen by examining any three-colour print with a lens. First of all a yellow impression is made on paper; then on the top of this a magenta or carmine impression, and finally on the top of this a peacock blue impression. Magenta on yellow gives red, peacock blue on yellow gives green, peacock blue on magenta true blue, while all three inks on the top of one another give black.

The Three Negatives.—There are many different processes of colour photography and variations of the different processes, some only of historical interest and others only of theoretical interest. The processes are still in course of development, and in the British Journal Photographic Almanac those interested will find references to investigations being carried on at present. But the practical methods hitherto developed which aim at a complete rendering of the colours all require three different photographic negatives. One highly successful method uses only two negatives, namely the Kinemacolor method of cinematography, but with two negatives the colours are not rendered so accurately as with three, and consequently three negatives are generally taken.

In taking an ordinary photograph, the picture is focused on the plate in the camera, and the plate is then exposed, developed, and fixed. The picture produced in this way is called the negative, because when it is held up to the light, it gives the rendering of light and shade reversed. The parts of the picture which should come out light are dark: the sky, for example, comes out black, so do white collars, while boots come out white. Now, in the case of an ordinary photograph, both visible light and invisible rays fall upon the photographic plate, red, green, and blue visible light, and ultra-violet invisible rays. But the ordinary photographic plate is sensitive only to the ultra-violet, the blue, and partly to the green. It is not sensitive to the red. Red letters on a dark background would not come out at all in the negative. It is because the plate is not sensitive to red that it can be developed in a red light. The single negative obtained in ordinary photography is produced by ultra-violet, blue, and some green rays all superimposing on the plate and producing a joint picture. Colour photography replaces this single negative by three separate negatives, one produced by each of the three primary colours, red, green, and blue.

The plates employed must be sensitive to red and green as well as to blue. So-called orthochromatic plates won't do; they, like Kodak and Ensign films, are fully sensitive to the green, but not to the red. As a

consequence of employing plates sensitive to red light, no red lamp can be used in the dark-room. The plates must be developed in darkness.

The three separate negatives may be taken (i) with an ordinary camera one after the other. In this case neither camera nor object must move during the three exposures. Or (ii), the three separate negatives may be taken simultaneously by means of a special camera provided either with three lenses or with an arrangement of mirrors. Or (iii), by means of a screen plate the three negatives may be taken simultaneously on the same plate with an ordinary camera; this is the method employed in the Lumière and Paget processes.

Method used in Three-colour Printing.—The first method is probably the easiest to understand, so we shall describe it first. A quarter-plate camera, for example, is set up before a vase of flowers, and a red filter, a sheet of coloured gelatine contained between two glass plates, that transmits only the red rays, is placed in front of the lens. Then an exposure is made. Next the plate is changed, a green filter placed in front of the lens, and another exposure made. Finally the plate is changed again, a blue filter placed in front of the lens, and another exposure made. We thus obtain three negatives, one made by each of the three primary colours. Now let a glass positive be made from each of these negatives, and let these positives be used as lantern slides and projected on a screen by three separate lanterns, each in the colour in which the corresponding negative was originally taken. A positive is a negative made from a negative, and consequently has the correct rendering of light and shade. The arrangement of lanterns is similar to the one described in connection with the mixing of colours, only instead of projecting three discs of light we are projecting a red, a green, and a blue picture. If now the red, green, and blue pictures are superimposed, we shall have a picture of the vase of flowers on the screen in approximately its natural colours. This is referred to as the additive process of reproducing the colours.

Again, if we prepare half-tone blocks from each of the three negatives, and make impressions of these blocks on a sheet of paper, each in the colour complementary to the filter through which the corresponding negative was taken, e.g. the impression from the block made from the negative taken through the red filter is in peacock blue, then we shall have a print on the paper of the vase of flowers in its natural colours. This is the method employed in commercial three-colour work. It is referred to as the subtractive method of producing the colours.

It is unfortunately not possible in DISCOVERY to give an illustration in colours, but the adjoining ten diagrams which the reader can colour for himself may help to make the matter clearer. (1) is the object, a red,

green, and blue flag nailed to a black stick, placed against a white background. (2), (3), and (4) are the negatives made through the red, green, and blue filters, i.e. by each of the three primary colours. (5), (6), and (7) are the positives made from these negatives. (8), (9), and (10) are the impressions made by the three blocks prepared from the three negatives.

When the three negatives are taken simultaneously, there is no difference in principle or procedure from the case in which they are taken one after another.

Lumière and Paget Processes.—The Lumière screen plate is an ordinary colour-sensitive plate covered with a layer of flattened starch grains. These grains are transparent, are coloured red, green, and blue, and are well mixed over the whole surface of the plate. The grains act as filters. They are invisible to the eye, but can be seen on examining the plate with a microscope. It does not matter where the filter is, as long as it comes between object and image. In the arrangement previously described it was in front of the lens; here it is on the plate. The light cannot get to the silver salt without passing through a filter. All the parts of the plate behind the red grains form a negative similar to that taken through the red filter in the method previously described. Only here the negative, instead of being continuous, forms a mosaic; it is mixed up with pieces of the other two negatives, and the area of each is less than one-third of the area of the plate.

After exposure the Lumière plate is developed and reversed. The image in the emulsion is converted into a positive by treating it with special solutions. The same plate that was the negative becomes the positive. We obtain, therefore, one plate which is a combination of the three positives produced by the method previously described. They are in the form of a mosaic, all mixed up. If this positive is put in a lantern and projected, it gives a picture of the original object in its natural colours. If it is held up to the window, it acts as a transparency giving a picture of the object in its natural colours. But there is no easy method by which it may be converted into a coloured print on paper.

The Paget method differs from the Lumière method in having the screen on a separate glass plate from the sensitive plate; consequently one screen may be used with a number of plates in succession. The screen is covered with little red, green, and blue rectangles forming a geometrical pattern. It appears colourless to the eye, but the rectangles can easily be seen under the microscope. They are much larger than the starch grains in the Lumière screen. The screen is held in the slide with its surface in contact with the plate. After the plate is exposed, it is developed, fixed, and a glass positive made in the usual manner. This glass positive is then combined with a screen, similar to that through which the original exposure was made.

The screen and positive must be carefully adjusted, so that they are accurately in register. Each part of the positive must be opposite a rectangle of the same colour, as the exposure of the corresponding part of the negative was made through. When positive and screen are combined in this manner, they form a coloured transparency which can be viewed by holding it up to the window, or which may be projected as a lantern slide. There is no easy way of converting this transparency into a coloured print on paper.

Anyone possessing a camera that takes one of the

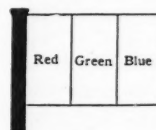


FIG. 1.

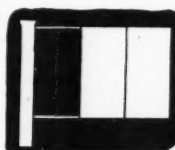
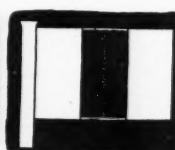
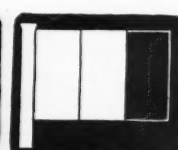
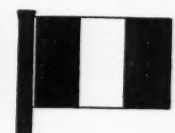
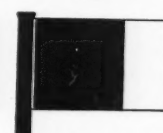
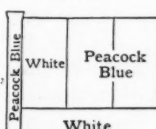
FIG. 2.
Negative through red filter.FIG. 3.
Negative through green filter.FIG. 4.
Negative through blue filter.FIG. 5.
Positive for projection in red.FIG. 6.
Positive for projection in green.FIG. 7.
Positive for projection in blue.

FIG. 8.

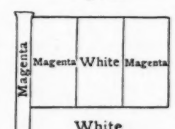


FIG. 9.

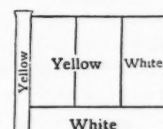


FIG. 10.

The three impressions in three-colour printing.

standard sizes of plates can make coloured transparencies with a little patience by either the Lumière or Paget processes, and many amateurs dabbled in these processes in the days before the war. But the drawback is the impossibility of making coloured prints. And there is also a difficulty in obtaining suitable objects to photograph. An English city contains comparatively little colour; perhaps the only bright colour in a street is a red letter-box or the coloured side-boards of a tram-car. And in the country, except at certain seasons, the colours are never saturated. So possibly the best rendering may be given by a sepia monochrome slightly tinted by hand.

The method used for three-colour printing is, of course, the method by which three separate negatives

are taken. The most interesting developments of this method are taking place at present in cinematography. Here it is no disadvantage not to be able to obtain a coloured print, and three lenses are not necessary to project the three coloured pictures. One lens can project all three one after another, so rapidly that they fuse into one. Similarly the three pictures can be taken in rapid succession by means of the same lens, and the elaboration of apparatus and difficulties of registration can be avoided. So that the prospects of success are greater here.

Colour photography is a subject on which the textbooks become out of date. It has been impossible in this article to do more than give an outline of it. Probably the best method for the amateur to obtain further information is by studying the literature supplied by the photographic dealers.

Orthopædic Surgery

By A. B. Appleton, M.A., M.R.C.S.

Senior Demonstrator of Anatomy in the University of Cambridge

(Continued from May No., p. 122)

WE find that already in the time of that pioneer surgeon-anatomist Hunter, when Mrs. Mabb drove her carriage and four into London¹ "to take charge of the dislocated limbs of the nobility and gentry," the medical profession was putting behind it the old secrecy which had characterised the alchemists and healers of old. It is only the pursuit of truth for truth's sake, and the publishing abroad for all to know of every treasure as it is unearthed, that has rendered possible modern medical knowledge and science. As time goes on, the difference of motive between quack and professional becomes still more marked, but even now a large proportion of educated men and women are ignorant of the altruistic spirit behind the spread of medical knowledge, and they readily condone the reticence of the quack. Such reticence, however, if there were anything to conceal, would be the enemy of all progress.

Diagnosis of the nature of joint disability is, then, of essential importance; if the bone-setter could form a rational diagnosis, he would avoid the cases which are made worse by manipulation; he would cure the appropriate cases only, and avoid the disasters which are inevitable with empirical methods.

Thorough manipulation is appropriate for cases where adhesions are present. But very similar

symptoms arise in a knee where the patient is suffering merely from loss of power in wasted thigh muscles. For these the orthopædic surgeon will not "manipulate"; he will prescribe a course of Graduated Contractions. Again, a torn "cartilage" or ligament may be present; if so, Graduated Contractions will not cure; but the condition may heal spontaneously after replacement, or it may need operation to remove the torn fragment. But if, after healing, the tear is reopened, there will this time be a greater liability to adhesion formation, and to weakening of the joint from fluid effusion, and this is aggravated every time the "cartilage comes out." A clear understanding of these circumstances requires the orthopædic surgeon of to-day to recommend operative treatment after trial has shown that replacement of the torn cartilage by manipulation has not resulted in thorough repair.

As in other spheres of surgery, we find in "diagnosis before treatment" the keynote of success; the nearer we can approach this ideal, the better shall we succeed. Owen Thomas, the son of an unqualified practitioner, spending his boyhood observing his father's treatment of joint troubles, later making a special study of bone-setters' methods, and noting their failures and successes, deliberately concluded that a knowledge of causes was necessary; that as a bone-setter he would never cure all cases, and that he must learn wherein the differences lay that he might cure all of them. Since his pioneer work, the mechanism of the knee-joint and the manner in which derangement occurs have become much more fully understood from the anatomical investigations of Hey, of Leeds, and Goodsir in Edinburgh. If only all the "medical practitioners of England had been familiar with the observations of William Hey, and grasped his method of treatment," says Dr. Keith,² "bone-setters would not now be flourishing in the West End of London."

There is another method of dealing with adhesions other than "manipulation," one which is most particularly applicable to tough or extensive adhesions, to contracted scars or to fibrous changes in muscles (ischæmic and other contractures). It has developed out of the methods of Owen Thomas, and is illustrated in Fig. 2,³ showing the later stages of a successful slow prolonged stretching extending over weeks. Such "continuous splintage" has been found to be vastly more effective for certain types of stiffness than the immediate forcible manipulation previously discussed.

The caliper splint, an offspring of Thomas's knee splint, has provided a means of making a lower limb functionate even when an incompletely repaired fracture is present, and when the full weight cannot

¹ Quoted by Dr. Arthur Keith, reference No. 2; see also p. 308 of the same work.

² See reference No. 2, pp. 319 and 323.

³ See reference No. 1.

be borne upon the limb. The side-bars are of just such a length that when the man sits on the upper end, a

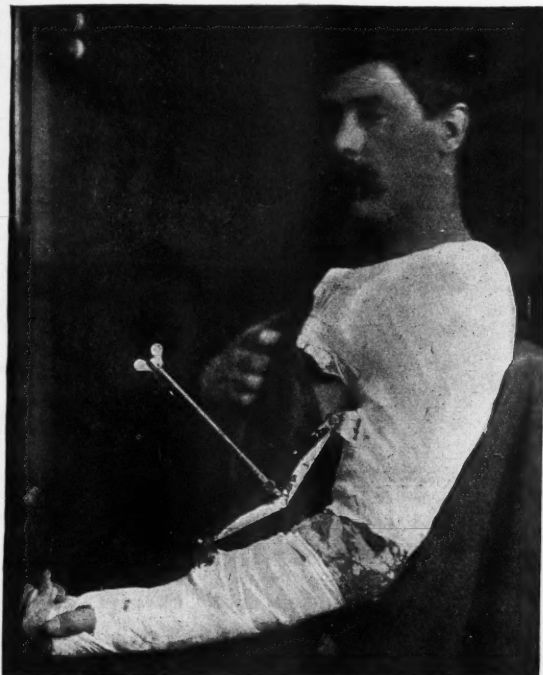


FIG. 2.

THE PATIENT, BY TURNING THE SCREW, HAS GRADUALLY STRAIGHTENED OUT HIS ELBOW.

(Reproduced by permission of the Oxford Medical Publications.)

small part (or none if desired) of his weight is transmitted through his own leg to the heel of the boot, and the splint prevents any shortening of the limb. Transmitted pressure, thus provided, is found to exert a very beneficial effect on the rate of bone-repair; for even a healthy bone becomes fragile if it is not permitted to withstand the stresses for which it is constructed. Elmslie¹ in London, and more recently Els of Bonn, have published cases in which bone-grafts have themselves grown to a much larger size from the effect of transmitted stresses.² It is of advantage, then, to the fractured bone, as well as a convenience to the patient, that he should get about at an early date in a caliper splint. It is of great use for similar reasons—the partial maintenance of natural functions—in other conditions besides fractures.

The treatment of limbs after injury to nerves has fallen within the scope of the orthopaedic surgeon on account of the deformities which follow the consequent

unbalanced muscular forces,³ and on account of the need for special treatment to the muscles put out of action by nerve injury. Apart from repair of the nerve, a grave problem is presented by the injury inflicted on a muscle by complete loss of activity, the wasting of muscles being in these cases extreme. Nor was it (till recently perhaps) a simple matter to circumvent this secondary effect of nerve injury. Muscles which have been cut off from the central nervous system show a series of changes which has been known as the "reaction of degeneration," a change which, it has been discovered, is in reality an increased minimum duration of the effective electrical stimulus to contraction. A normal muscle is sensitive to electrical stimuli of very short duration. If one (electrical) pad is placed on the "motor point" of an arm muscle, and the other terminal moved about over the belly of the muscle until the optimum position is found, an impulse lasting only $\frac{1}{240000}$ second of a 100-volt potential will cause a definite contraction. But after six weeks' deprivation of impulses through its nerve, this muscle



FIG. 3.

ABDUCTION SPLINT FOR USE WHEN THE ARM CANNOT, OWING TO NERVE INJURY, BE LIFTED FROM THE SIDE.

(Reproduced by permission of the Oxford Medical Publications.)

¹ See reference No. 3 at end of article.

² Bond, of Leicester, and Huntingdon, of California, published the first cases in 1905.

³ See Fig 3.

will scarcely respond to a stimulus lasting $\frac{1}{1000}$ second. An important practical result of this influences our procedures for treatment. Such a muscle will not, in fact, respond at all to the average effective impulse derived from a faradic coil, lasting $\frac{1}{1000}$ second; we are therefore precluded from the use of an ordinary coil for the purpose of giving Graduated Contractions, which would have been an ideal method of maintaining condition in a muscle. It has not yet been ascertained how long it is necessary for a nerve-path to be blocked in order to render a muscle insusceptible to the faradic stimulus; during the period, however, in which a nerve whose two cut ends have been sewn together is in process of recovering its functions, there is a

adhesions of joints, of muscle-tendons to their sheaths, and of muscle-wasting as with any other cause of immobilisation; but the muscle-wasting is infinitely more serious, the muscles require a special type of electrical stimuli for their contraction, and the period of treatment must continue till the nerve has been repaired and is able to conduct voluntary impulses.

Exhaustive study, by the late Dr. Lewis Jones, of the problem of obtaining a standardised instrument as regards impulse length voltage and rate of interruption, which would supply impulses of any required length, resulted in the production of his condenser apparatus, which in turn has undergone some slight further modifications. It is only by such an instrument that any satisfactory investigation

of the exact condition of a muscle is possible. With its help we can detect defect in a muscle which appears to respond well to voluntary effort; we can ascertain improvement in a muscle which is still unable to respond to impulses from an induction coil. It completely alters, in fact, our position as regards the investigation of degenerative changes in muscles following enforced inactivity.

Methods of repair of nerve have of late received much attention, but must be here passed over with scant attention. The problem of making up for a gap of several inches in a divided nerve has been a constantly recurring one in war injuries, and the value of nerve-grafts is still subject to much discussion. Considerations as to the method of repair of nerves, the downgrowth from the proximal portion into the peripheral portion (which serves merely as a pathway to conduct it to its destination) when the cut ends are brought together, makes it likely that

grafts serve a similar purpose, conducting the new outgrowing fibres into the separated distal part of the nerve. It is possible that other devices may prove quite as successful. As implied above, long periods are found to be required for the fresh outgrowth of nerve fibres from the cut end along the old path, up to eighteen months in the leg, depending on the distance they have to travel before reaching their end-organ in the muscle. The nerve-fibres appear to be absolutely dependent on their connection with the central end for function, growth, and life itself.

There are within sight at the present time great possibilities for the use of bone-grafts. We can transplant pieces of bone, with the correct technique, cut them to any required shape, and implant them after the manner of a cabinet-maker's art, with the

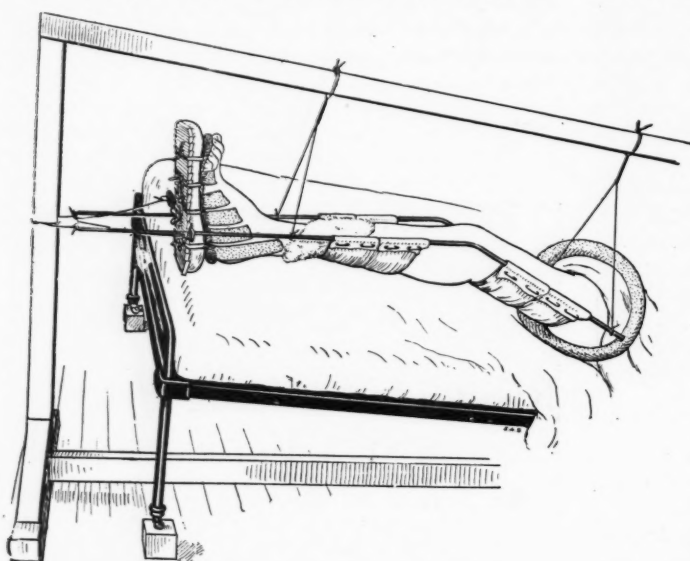


FIG. 4.
TREATMENT OF COMPOUND FRACTURE OF LEG ON THOMAS'S SPLINT
SLUNG FROM A BALKAN BEAM.

Extension is made from a Sinclair's Foot-piece.

(Reproduced by kind permission of Messrs. Baillière, Tindall, and Cox.)

period of months during which a long impulse, such as that ordinarily obtained at make or break of a galvanic current, is necessary for contraction. During this period, then, daily stimulation of the affected muscles is necessary, the galvanic current being employed until response is obtained with the faradic current; both are then employed for a time till finally the faradic current is employed alone as described under the procedure for Graduated Contractions. Resisted exercises form the last stage of treatment for the recovering muscles upon the return of voluntary power.

The same considerations apply, then, to the care of a limb immobilised from paralysis through injury to a muscle-nerve as apply to the care of a limb with fractured bone. There is the same liability to

practical certainty that they will live in their new surroundings. Absolute freedom from germs is a *sine qua non*, especially in bone-surgery, and it requires "surgically clean" surroundings for its success; but these conditions are attainable, and the method is frequently applicable to the repair of fractures. Whether dead bone will succeed as a graft as well as live bone is a point requiring investigation; certain facts point to the purpose of the transplanted bone as no more than a scaffolding for the ingrowth of neighbouring live bone, in which case boiled pieces of bone derived from a sheep should be as successful as live bone from the shin of the patient. A curious fact has come to light, however; a bone-graft is alive three months after transplantation, a date which seems early for the ingrowth into it from its surroundings of live bone-cells. Yet such a graft undergoes active repair at this date, after fracture, as only live bone can do. The explanation of such facts and the possible sources of such ingrowing bone-cells, if any, provide much scope for further investigation.

The subject of bone-grafting, so highly developed as a surgical technique by Albee in America, with his twin motor saws, etc., cannot be dismissed without reference to his treatment of spinal tuberculosis. Here absolute immobility is the goal of all methods of treatment, in the hope that the disease will then become quiescent. Plaster-jackets and the recumbent position in bed have long been tried, without complete satisfaction. But it would seem that the bone-graft, long enough when adherent to the spine to make it a rigid column, will help to solve the problem, which is, it must be said, one of the most difficult in orthopædic work. With the mention of the "plaster bed," a "bed" accurately moulded on to the patient's back, and in which he can lie without disturbance for a month at a time without danger of pressure-sores forming such as occur so easily in a bed-ridden patient, we must dismiss spinal tuberculosis. Its importance and its difficulties are not to be measured by such brief consideration as ours.

Difficulties also surround the provision of suitable artificial limbs for amputation stumps prepared by the brilliant kineplastic methods of the Italian surgeons. Movable nobs and pulleys are prepared from the live tissues themselves, the pull of an individual muscle being "harnessed" to the nob and so rendered capable of transmission, for example, to the thumb of an artificial hand. These are more successful when a small piece of bone can be incorporated in the "nob," to render it more substantial, but the gravest limitation lies in the difficulty of designing suitable artificial appliances.

The value of baths of different temperatures, of whirlpool baths, must be mentioned when effects upon

the circulation are desired or when either stimulating or sedative effects are required. They form a useful preliminary to the administration of massage. Extensions in the employment of electricity in various forms must be similarly passed over without further consideration.

The rise of orthopædic surgery, as we have seen it, has been the outcome of anatomical studies of the exact arrangement of parts, of experimental investigations as to the behaviour of muscle, bone, and other tissues under normal and abnormal conditions, and the application of knowledge so gained to the treatment of an increasing variety of disabilities. Exact diagnosis precedes surgical treatment just as education in the use of restored or reconstructed parts must follow it.

Solid foundations are being laid where once there was a house built upon sand; but the building of the superstructure has scarcely yet begun.

BOOKS OF REFERENCE OR FOR FURTHER READING

- (1) *Treatment of Joint and Muscle Injuries.* By W. Rowley Bristow. (Oxford University Press, 1917, 6s.)
- (2) *Menders of the Maimed.* By A. Keith, M.D., F.R.C.S., F.R.S. (Oxford University Press, 1919, 16s.)
- (3) *The After-Treatment of Wounds and Injuries.* By R. C. Elmslie, M.S., F.R.C.S. (J. & A. Churchill, 1919.)

Rising and Falling Prices— and a Remedy

By Arthur R. Burns, B.Sc. (Econ.)

I

ECONOMICS, the science that treats of the facts and conditions of the material side of daily life, seems a somewhat unpromising direction in which to seek discovery with all the essential suddenness of advent and revolutionary effect with which it is associated in the physical sciences. In spite of this, something very much akin to discovery, or perhaps, more properly, invention, has been made by Professor Irving Fisher, who has been working for some years at the Yale University on the problem of money and the devising of a scheme to eliminate the serious inconveniences of rising and falling prices.

The organisation of society is to-day so vastly more complicated than in the days when money was first invented that, before we can fully appreciate either the problem Professor Fisher has been attacking, or the merits of his invention, it will be well to look back to those early days. We shall then be better able to realise how much has now come to depend upon the

unit of money and how money has been bearing its burden.

The invention of money was made far back in antiquity and originated in the great difficulties that arose under a system of simple barter. Any measure of freedom and ease in the exchange of goods made it necessary for some commodity, or commodities, to be commonly acceptable in exchange for things which individuals desired to acquire. Although in various times and places many different commodities have passed as currency, certain metals have proved most suitable for this purpose, and gold and silver—the “precious metals”—have been the most widely used. Both have been eagerly sought after for purposes of personal adornment, and their comparative scarcity has given them a high value. The weight and bulk of these metals needed to carry through normal transactions is thus rendered reasonably convenient. While both metals have been used for currency purposes from early times, at the commencement of the Christian Era, and for many centuries, silver was the metal more commonly used in England and on the European continent. During the nineteenth century circumstances (including the discovery of supplies of gold in California, Australia and, later, in the Witwatersrand) caused gold to gain much in popularity for currency purposes. For a period of about forty years prior to the outbreak of the Great War, gold was the basis of nearly all currencies in the world.

While, before the war, gold was in circulation in this country as a currency, in reality it was used only to a very small extent in the settlement of private and, to an even less extent, of business transactions, in proportion to the amount of business done. For transactions within the United Kingdom cheques were used for the settlement of the greater volume of debts. In the settlement of debts due to and by persons outside the United Kingdom, i.e. in settlement of foreign trade transactions, the bill of exchange largely fulfilled the functions of the cheque at home. In addition, it fulfilled other functions with which it is not here necessary to deal.

When the cheque was invented in this country by the goldsmiths in the City of London in the seventeenth century, it was merely an order by a customer instructing the goldsmith to pay a creditor of the customer a certain sum out of the money left with the goldsmith for safe keeping. The goldsmiths found that, although customers were always withdrawing and depositing money with them, yet, on balance, there was always a considerable sum which was not, in the ordinary way, required by customers. As a result, they began the practice of lending out for their own profit so much of this steady balance as they considered it safe to part with. If they lent out too freely they

found themselves, sooner or later, with insufficient ready money to pay a customer's cheque and had to suspend payment. In this practice of lending balances commenced the practice of banking as distinct from the provision of safe deposit facilities for money. To-day the relending of customers' money has developed very far in this country. Bankers lend part of the funds entrusted to them by their customers to other customers—by allowing these latter to draw cheques upon them for an amount greater than the deposits of the borrowing customer, i.e. by allowing overdrafts. Money is also lent by them in other ways—by purchasing securities and by providing funds to persons whose function it is to relend them in the facilitation of trade transactions (by discounting and lending on bills of exchange). If it had been compulsory to use gold in the settlement of all debts, trade upon the present scale would have been impossible, for there was sufficient gold in this country in 1914 to pay only a very small percentage of the amounts which bankers owed their customers. Bankers still endeavoured to arrange their business in such a way as always to be able to supply gold when it was demanded, but now, in the knowledge that any great demand for gold was improbable, they relied mainly upon being able to get gold from the Bank of England, which relied largely upon its power to set in motion influences that would check the demand for gold. To attempt the task of paying out simultaneously in gold all the sums it owed would have been attempting the impossible.

Thus, for all practical purposes, cheques formed a very great addition to the gold currency of the country. In the days before the goldsmiths relend the balances in their hands, cheques, if passed from hand to hand, merely represented a portion of the gold in the vault below the goldsmith's shop, and were not an addition to, but rather a temporary substitute for, the gold coins. The amount of this addition to the gold currency is decided by bankers when they determine the extent to which they will relend the funds in their hands. They cannot, of course, lend more than the total deposits with them; they dare not lend nearly all these deposits—or how are they to meet their customers' demands day by day? They must clearly make some decision—endeavouring to lend as much as possible in order to make as much profit as possible and yet always keeping ample funds to meet all demands.

Bank of England notes were also, before the war, an important part of our currency system; but as all notes in excess of an amount fixed by an Act of Parliament of 1844—and termed the “fiduciary issue”—were represented by actual gold at the Bank, these notes were in the nature of mere safe deposit receipts for gold in the same way as the original cheques on goldsmiths.

Small change moneys of silver, nickel, and bronze are

accepted only to a limited extent, and may, therefore, be ignored for the purposes of the present article.

Having now discussed the elements which go to make up the currency supply of the country, we may pass on to the relation between this supply and prices in the country. In most transactions money forms one side of the bargain—when an article is sold for money it is just as logical to say that the money has been sold for the article. The most obvious and generally applicable way of making a commodity cheap is to increase the amount available for exchange. This applies equally to money, and if the quantity of money available be increased, then its value will tend to fall, or, we shall say prices are rising—for we shall be compelled to give more of the less valuable pounds to obtain a commodity than before the change took place. If, however, the amount of work to be done by the money (the amount of goods and services to be purchased) be also increased, then a neutralising influence would come into force and the result of the two opposing tendencies would depend upon the quantities concerned on either side. On the other hand, by decreasing the amount of money available, the purchasing power of the money would tend to be increased and prices tend to fall.

There is also another way in which monetary conditions may affect prices. Money is used over and over again—every recipient again paying it away in a greater or lesser time. It can easily be seen that by a general increase in the rate at which people “turn their money over,” a smaller amount of money may be made to do the same work as was done by a larger amount when the circulation was sluggish—or, if the rapidity of circulation be increased without any reduction in the amount of money, the effect will be the same as if the amount of money had been increased and a rise in prices will result.

In actual fact, the assumption above made that the amount of goods for sale shall remain unchanged cannot, of course, be made. General prices are thus determined by the quantity of goods and services to be sold on the one hand and the amount of money and the rapidity with which it is being turned over on the other. We have already seen above that money must be understood to include not only gold, but cheques and bills and all instruments used for making money payments and which pass freely as currency. We have also seen that the amount of the cheque circulation (or, in its more general name, the volume of credit) is determined by bankers, as they decide from day to day how much of their customers' funds they will relend. If bankers choose to allow very large overdrafts to their customers, the customers would be given great power to purchase and would drive up prices. If, however, the bankers did this, they would not only cause prices to rise, but they would also, when the time

came to honour the cheques, have to face heavy demands upon themselves, and would ultimately find that only a very small portion of the funds originally lent to them by their customers was in a form in which it could be used to pay back these customers, should they require their money. Thus while the bankers can and do, by increasing and decreasing the amount of purchasing power available, cause increases and decreases in prices, they are always held back by the fact that they must keep a reasonable and safe proportion of their funds in a “liquid” condition, as we explained above.

An increase in the amount of gold available increases purchasing power in the same way as an increase of credit, but such an increase has also a further and secondary tendency to increase purchasing power, owing to the fact that credit is based ultimately upon gold and the increased reserve of gold acts also as a basis for further credit.

The price of any individual commodity, however, may be influenced by a great number of factors, which may affect either the supply of that commodity or the demand for it. The price of wheat may well be affected by weather conditions in the wheat-producing areas, or changes in the habits of the people involving a greater or less consumption of wheat. All prices are, however, expressed in the terms of currency, but sellers accept currency for their goods or services only because they know that they can obtain the goods or services of which they are themselves in need in exchange for the currency. The real price which they get is, therefore, the goods or services which they can obtain by spending their currency. This is determined, however, not only by the factors which decide at what price they can sell their product, but also by what they can obtain in exchange for the currency in which they are paid. In dealing with any one commodity, it may often be difficult to decide whether changes in price have been due to changes in the conditions of the supply of or demand for the commodity, or changes in the purchasing power of the currency. If this purchasing power falls, i.e. if general prices rise, sellers will find that, unless they raise their prices expressed in currency, the real prices they are getting are falling and they “cannot live.” A rise in the purchasing power of the currency will raise their real prices and competition will tend to force them to reduce their money prices.

Until comparatively recently there has been no satisfactory method of ascertaining whether changes in prices have been due to changes with regard to each commodity or changes due to currency conditions. A convenient method of doing this is now to hand in the familiar “index number.” The principle upon which the index number depends is that, if we find that the prices of a number of commodities, all affected by

different supply and demand influences, show a common tendency to rise or to fall, then it is fairly safe to assume that the change has been in the currency in which the prices are expressed, and not in each commodity.

The general idea is well illustrated by the fact that it was once believed that, because the stars all appeared to move across the sky, the earth was at the centre of the universe and the heavenly bodies moved round it. It is now thought more reasonable to suppose that it is we who are moving by reason of the revolution of the earth and that the stars are relatively fixed.

(To be continued.)

BOOKS

Stabilising the Dollar, by Irving Fisher. (Macmillan, 18s.)

The Purchasing Power of Money, by Irving Fisher. (*Ibid.* 12s. 6d.)

The Place and Power of the Cerebellum

By D. Fraser Harris, M.D., D.Sc.,
F.R.S.E.

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THE functions of the cerebellum were for a very long time a mystery; our anatomical knowledge of it was so much more detailed than the physiological, a state of matters that has been the usual rather than the exceptional as regards most organs of the body.

The cerebellum, which is below the cerebrum, and protected from its pressure by a stout sheet of connective tissue, the tentorium, is composed of two lateral portions, the hemispheres, and a single central mass, the vermis. Each half of the cerebellum is connected by many nerve-fibres to the cerebrum above, to the spinal cord behind, and to the brain-stem below, the superior, inferior, and middle peduncles respectively.

The cerebellum sends nerve-fibres to the cerebrum by a crossed path, and the cerebrum sends fibres by a different and more roundabout crossed path to the cerebellum. These reciprocal relations are of such a kind that when one-half of the cerebrum, say the left, does not develop, the opposite, or right, half of the cerebellum remains undersized.

The cerebellum is also abundantly related to the body through certain tracts of the spinal cord, the chief connection being with the skin and muscles of the body by tracts which do not cross; that is, the left side of the body is represented in the left half of the cerebellum and the right in the right. The right half of the cerebellum is, therefore, connected with the left half of the brain, but with the right half of the body. Now, it will be remembered that the left half of the brain governs the right half of the body. The muscles of

the head, neck, and trunk are represented on both sides of the mid-line in the central parts of the cerebellum, those of the limbs in the lateral parts.

The cerebellum is late of appearing in the nervous system as we ascend the animal scale. As one might expect, it is relatively very large in the birds, creatures to whom the maintenance of an accurate balance is so very important. The fishes, for instance, have the cerebellum better developed than have the reptiles, in which group it cannot have much functional importance.

Let us now try to make out what these various connections of the cerebellum to other parts of the nervous system mean. In the first place, injuries to or diseases of the cerebellum do not produce any impairment of a person's sensations. Animals from which the entire cerebellum has been removed do not suffer any loss of sensation. A man with congenitally undeveloped cerebellum has no diminution of delicacy of sensation. The cerebellum is, therefore, not the physical basis of the elaboration of sensations, nor does it aid in that process.

But numerous nerve-impulses travel over the paths which reach the cerebellum through the spinal cord from the body—impulses, therefore, which are afferent but not sensation-producing or sensificatory. The cerebellum receives but it does not perceive. Muscles, joints, skin, viscera, and those curiously complicated "semicircular" canals, a part of the internal ear which have to do with balancing, all send their impulses to the cerebellum. But they also send impulses which go to the cerebrum and give rise to sensations of different degrees of distinctness. So that the state of matters seems to be this: while certain organs send impulses to the brain to contribute to consciousness, these same organs simultaneously send impulses to the cerebellum, which do not give rise to consciousness.

We cannot, therefore, speak of the cerebellum as being "aware" of anything; there is no simple word to express what exactly the cerebellum does as regards afferent impulses. It receives them from many parts of the body and "works them up" or correlates them without their arousing consciousness at all. The cerebellum receives afferent but not sensificatory impulses, and dealing with them subconsciously, relates them to outgoing impulses.

Let us in the next place see what is the state of matters on the efferent or motorial side. When a portion of the cerebellum is injured in an animal, the animal does not suffer from paralysis of any muscles, but from a clumsiness of movement and an awkwardness of muscular action. When this awkwardness is brought out in the arms as a test in clinical medicine it is called "adiadochokinesia." The muscles have, indeed, rather less tone than before (atonia), and their movements are somewhat inco-ordinate, or ataxic.

If the entire cerebellum has been removed, the animal cannot maintain its balance either in a state of rest or of motion; and if one-half of the organ has been removed, the animal has tremor of the muscles on that side and tends to fall towards the side of the defect.

In man, injury to the cerebellum, according to its gravity, leads to more or less extensive inco-ordination of muscles, or ataxia, especially in the legs, so that the equilibrium of the body becomes unstable, whether the body be at rest or in motion. His muscles are not paralysed, and he can move them voluntarily as before; but if the cerebellar disease be at all serious, he walks with a staggering gait like a drunken man and strives to keep his legs far apart because this widens his base of support. This, of course, he does consciously; his straddling gait is the conscious compensation for the results of the subconscious irregularity in the cerebellar mechanism for the maintenance of the equilibrium of the body. The gait in cerebellar ataxia is characteristic, the head lags behind the torso and the torso behind the legs. Although, then, the cerebellum is not the seat of awareness of bodily states, and not the organ which originates bodily actions, yet it seems to be an important organ in the co-ordination of muscles which steady the body whether at rest or in motion (static or dynamic equilibrium).

The cerebellum sends no motor impulses to muscles or to any other "effector" organs, as far as is known. Efferent tracts do, however, leave it, not for the muscles directly, but for them indirectly via the cerebrum. The cerebrum controls the muscles, decides whether they shall merely leave the body at rest or balance it as it moves about; but all the time the cerebellum, in its turn, apparently controls or influences the cerebrum. For instance, it has been noticed that when the cerebellum has been injured, the cerebrum is apt to put forth either too little or too much nerve-energy, and so produce ataxia by deficiency (adynamia), or ataxia by excess (over-action, over-compensation).

The study of the behaviour of a large intelligent animal which has suffered the loss of one-half of its cerebellum is instructive. Let us suppose that an adult dog has had its left cerebellar hemisphere removed; for the first few days it cannot stand properly, but falls over on the left side. The eyes are not at rest, but oscillating; the muscles of the left side are tremulous and rather weaker than usual, though by no means paralysed. By degrees the dog gets better; the tremors are less severe, and finally he learns that he can prevent himself falling over if he walks towards the wall and leans up against it. This is intelligent compensation for the defect of impaired maintenance of equilibrium; it is possible only because the animal's cerebrum is still intact.

Again, a dog with only half of the cerebellum intact,

if thrown into the water, will swim more or less like a normal animal. It is noticed, however, that the dog does not go in a straight line, but in a curve which bends towards the sound side. The reason for this is interesting: dogs swim not like men, but by "grabbing" the water with their fore-paws. The muscles on the sound side, having more tone than those on the other, allow the paws to catch hold of the water better, with the result that if it is the left cerebellar half that is gone, the dog swims away towards his own right.

Muscles in human cerebellar disease are not paralysed, but they are tremulous and to greater or less extent show diminished tone and force (adynamia). The same facts may be brought out by another device: if the dog above referred to be now made to walk on the hard ground, he is seen to be deviating towards his own left. This is because the right-sided muscles, having the better tone, get a better push-off from the ground than do the opposite ones, and so in time cause the animal to walk away from the straight line.

A curious thing was noticed about the dog made to swim. After a certain number of trials it was learning to swim straight. The dog found that it could steer itself by means of its tail. It used its tail as a rudder, curved in this case towards the left in order to bring its body over to the side from which it was drifting. A dog, one of whose cerebral hemispheres has been removed, cannot do this.

But the cerebellum receives impulses from regions other than the periphery; it receives them also from the cerebrum. When the cerebrum is sending down nerve-energy to the muscles to maintain their tone or put them into activity, it sends simultaneously some energy over to the opposite half of the cerebellum.

The meaning of these various paths into and out of the cerebellum is probably somewhat as follows:

The cerebellum is informed of the state of tone or of contraction of the entire musculature of the body at any given instant; if, for any reason, it is necessary to increase that tone, the cerebrum has to emit fresh impulses, but just how intensely it must do so will depend on the amount of innervation which is sent over to it from the cerebellum (augmentor function); if, however, from any cause the cerebrum has been innervating the muscles too intensely, then it receives impulses from the cerebellum to restrain the intensity of its energy (inhibitory function).

The cerebellum is, as regards the cerebrum, a kind of "centrifugal governor": if the cerebrum is not doing enough in the way of innervating muscles, the cerebellum intensifies its activity; if it is doing too much, it cuts it down, and all this below the level of consciousness.

The cerebellum is, then, not so much an organ for maintaining equilibrium as an organ corrective or regulative of the intensity of central motorial innerva-

tion. It is functionally an intermediary between the muscles and the cerebrum, but in order to be such it must be constantly informed both of the state of the muscles and also of the cerebrum in regard to the output of its energy from the latter. These conditions are fulfilled by the numerous afferent paths to it from the muscles and from the brain.

Reviews of Books

English Philology in English Universities. An Inaugural Lecture delivered in the Examination Schools. By HENRY CECIL WYLD, M.A., B.Litt., Merton Professor of English Language and Literature in the University of Oxford. (Clarendon Press, 1921, 2s. 6d.)

This inaugural lecture breaks new ground in its examination of the state of research in English philology and in its statement of policy with regard to the teaching of that subject at British universities. The pronouncement, coming as it does from perhaps the most distinguished living English philologist, merits the closest attention from all those interested in the teaching of language, and in the propagation of linguistic study. Professor Wyld holds, and we think he holds rightly, that all is not well with University methods and curricula when they do not succeed in inspiring "students with the desire or the capacity to make any serious contribution to our knowledge of any of the difficult special problems connected with" O.E. and M.E. dialects, and their distribution, or with their grammar and phonology. "Concerning the vital question of the origin and development of the literary dialect, which emerges during the M.E. period, there is hardly a single contribution by an English writer." Sweet and Ellis laid the foundations of the study of N.E. pronunciation and of the history of English sounds, but "nearly all the recent work on the modern period has been done by foreigners"—Horn, a German, Professor Jespersen, a Dane, Professor Ekwall and Dr. Zachrisson, both Swedes. Of living English scholars, among the younger men Dr. Chambers and Professor Sedgefield are producing solid work on textual lines; Professor Mawer has recently published a very notable contribution to the study of place-names, while Professor Wyld himself is revolutionising opinion about the distribution of dialect-features in M.E., and constantly making additions to the knowledge of phonology. Finally, the Oxford English Dictionary, its editors and assistants are on the verge of completing the greatest modern monument of English philological study. But even, if to these we add the names of the scholars of the last generation, notably those of Sir Henry Murray, Professor Napier, Professor Craigie, Dr. Bradley, and Professor Wright, it is clear that the promise of the work of Sweet, Skeat, Morris, and Ellis has not been fulfilled.

Mr. Wyld evidently favours the separation of the School

of English Literature from the School of English Language, and holds that it is "beyond dispute that the studies of literature and philology appeal respectively to different types of mind." Of this the present writer is by no means convinced, especially in the earlier stages. Indeed, Mr. Wyld might himself be taken as an example of the scientific philologist with strong literary bent and critical discrimination. Moreover, as things are, and must inevitably for some time remain, it is impossible to discover budding philologists before they come up to a university. Consequently it is desirable that all students in the English Honour School shall follow the same course of instruction in both branches of the subject until they have reached a stage when they are competent to choose between them, and to specialise in one or the other. Less objection can be taken to Mr. Wyld's attack on "the conception of English philology which is expressed by the syllabuses of our universities at the present time." It is an indubitable fact that emphasis is usually laid on the wrong things, and that the curriculum imposed does not represent the progressive nature of the subject, which is too often presented as something lifeless. When so-called "historical grammar" deals mainly with problems of primitive Germanic philology, while New English phonology is almost entirely neglected; when undergraduate students of English—not of Germanic—philology are expected to know the details of Gothic accidence and pre-Gothic sound-laws, while they treat the English language as if it had become ossified in the time of Chaucer, there is surely something wrong in our methods of presentment and our attitude towards the study. No true teacher or scholar but will agree with Mr. Wyld, that the right method is to get away as soon as possible from the atmosphere of textbooks and lecture notes, and to show the student "how and where the facts have been discovered, and make him understand why such and such inferences have been drawn from them." "Under the direction of his teacher the student will begin the work of research—the solution of simple problems, the searching out of facts not too hard of discovery—it matters not whether they have been discovered before or not; the main thing is that the young student should carry out the operation for himself, and should thus put into practice the scientific methods in which he is being trained." "The first and last word in our aspirations for the future progress of our studies is Research. This is the life-blood of all learning."

Mr. Wyld's plea for the proper endowment of teaching libraries is one that will be endorsed by all whose lot lies in the new Universities. When the sum allowed annually for the purchase of English books and periodicals, both literary and philological, for the central University Library, varies in most of them between £20 and £40, without any provision at all for a class library, there is no possibility of giving that insight into the methods of research which is the first need if there is to be progress. It is generally realised that natural science must have at any rate the essentials of laboratory accommodation and outfit. Until philology and literature—not to

mention the other Arts subjects—are given the same opportunities, that is to say, until there is access to the minimum of necessary books, humane learning will not and cannot flourish at the new universities, but will atrophy and die as the spirit of eager inquiry is replaced by belief in the formulae of textbooks. Mr. Wyld does not speak too emphatically when he says that “the establishment and further development of these Teaching Libraries is not a mere luxury, desirable indeed, though of secondary importance, but a necessity of the first urgency at the present time, if the study of English philology in this country is ever to become a reality and to yield fruitful results.”

Finally, since it is impossible to discuss all the interesting points made in this lecture, we would call attention to the extremely valuable suggestions about “fruitful lines of research which are open to the student of English Philology.” As may be imagined by those who know his work, Professor Wyld does not consider the editing of texts as the first need. He urges rather the publication of a series of minute studies on the dialectical distribution of elements of vocabulary, and of well-marked dialect-features; the importance of place and personal name studies; and, above all, the primary necessity for the investigation of M.E. and N.E. sound changes, involving a minute study of documents from about 1400 onwards. Further, he points out the absence of any adequate inquiry into colloquial idiom from Chaucer’s day to our own, and, allied with this, the question of the relation of literary and received standard spoken English to the various other forms of spoken English, regional and social. The field of research is large enough to provide work for all comers. It is the business of the universities so to reorganise English philological studies that the labourers may be ready for their task.

If Professor Wyld is able to work on the lines he has laid down in this inaugural lecture, then the University of Oxford should lead the way in the revival of philological studies in Great Britain.

EDITH J. MORLEY.

Symbiosis. A Socio-physiological Study of Evolution.

By H. REINHEIMER. (Headley Bros., London, 1920.)

It is one of the easiest and the most unfortunate things in the world to allow oneself to be run away with by an idea. If we were to translate it into biological terms, a proceeding which I am sure would meet with the approval of our author, we should have to call it over-specialisation; and over-specialisation, as all we biologists know, lies perilously near to extinction. Mr. Reinheimer believes that he has found the secret of all evolutionary truth. Now, it is always dangerous to think that our own pet theory is going to explain the universe, or, indeed, any considerable portion of its workings. Of course it may do so, and then we are Newtons, or Kants, or Darwins, or Einsteins. But we are so much more likely to have got mounted on a Hippogriff of the worst disposition, which is running us off into the most outlandish places (though all the time we think that we

are in perfect control!), that it behoves us to be very careful whenever one of our thoughts begins to move with that seductively exhilarating speed.

Mr. Reinheimer’s Hippogriff is, it must be admitted, a glorious beast. From his back, Mr. Reinheimer believes that he can see the why and wherefore of biological progress and extinction, the time-map of life, spread in all clearness beneath him.

Briefly, his thesis is this: that co-operation between members of different species—in other words, symbiosis in the broadest sense—is the only mode of existence which makes for biological solvency and biological righteousness. He believes that you can draw up a system of Evolutionary Economics, and can see which modes of life result in an excess of expenditure over income, which lead to a growth of capital; nay, more, that an ethical flavour may be properly introduced into our evolutionary thinking, since only through symbiosis does life achieve its true destiny, which is progress.

Now, Mr. Reinheimer is right in a number of very important points. He has seen the wood that so many professional biologists fail to perceive for the trees—he has a clear idea of biological progress; and he has gone further than that, and stressed in a very original and suggestive manner the value of biological co-operation, of symbiotic modes of existence, for achieving such progress.

But, then, the Hippogriff has taken the bit in its teeth. In the end, our author cannot allow that anything but symbiosis is good, and tries to apply his thesis, like a quack medicine, to all things singularly and collectively.

Not content with his interesting suggestion that symbiosis is a contributory cause of progress, he insists that an opposed mode of life is definitely the cause of eventual decay and extinction. However much a carnivore may flourish for the time (and that whether it eat flesh or be a “plant-carnivore,” i.e. a herbivore which devours without making its proper symbiotic “bio-economic” return), yet it is sowing within its constitution the seeds of its inevitable biological destruction. In some remarkable way, which is to be commended to the notice of bio-chemists, foods differ in their nutritive properties, and somehow affect the constitution of the species differently according as they are manufactured in the holy bonds of symbiosis or illegitimately and non-symbiotically. A quotation will give his point of view:

“... they [the ductless glands] require to be supplied by the organism with raw material that avails to life in the fullest sense of the word. . . . And such ‘tutored’ food, increasing in adequacy with every higher degree of Symbiosis, and ideally equipped with potencies diffusable [*sic*] with great benefit and without injury over the co-evolved animal body, can only be obtained with the help of symbiotic vegetable partners. . . . We may take it that great irregularity of glandular action . . . is the norm amongst predaceous species, which as the result . . . are in the end left with diminished strength and endurance, and with uncouth, ill-shaped bodies” (as, for instance, a tiger?).

Frankly, this sort of thing won’t wash; and it washes less and less the more we look into it.

He quotes Maeterlinck as an authority on seed-dispersal. Maeterlinck rejects the idea of natural selection altogether, and prefers to speak as follows: "In seeds disseminated by birds 'we see developed such a powerful reasoning faculty, such a remarkable understanding of final causes, that we hardly dare dwell upon it. . . .'" To which our author adds: "This interpretation enables one to understand how the plant is able to communicate a share of its vital psychic equipment to the animal. . . . The animal takes in knowledge with its food, as it were—essential knowledge—which is 'pre-digested' by the plant." And so we are introduced to the stupendous idea of mind-vitamines, which interesting but hypothetical substances, in conjunction with Samuel Butler's mnemonic theory of heredity, are to explain many remarkable facts—their lack, for instance, accounting for the sterility of hybrids (p. 105).

Later (p. 198) he introduces "the expression f/w ($\frac{\text{food}}{\text{work}}$) as a way of representing a norm of behaviour *upon which almost everything in Biology depends*" (italics ours).

That is just it—Mr. Reinheimer wants to explain "almost everything in Biology" by means of his "bio-economic law." And almost-everything-in-Biology steadily refuses to lend itself to explanation by any single principle. It is too complex for that. Mr. Reinheimer never seems to have mastered the idea of Natural Selection properly, and recent work on Genetics is scarcely mentioned. He reads widely but uncritically; H. F. Osborn is quoted as an authority on one page, to be followed by Maeterlinck on the next; Lankester and Bergson, Samuel Butler and Metschnikoff all apparently vie with each other as supporters of his theory.

It is a thousand pities that Mr. Reinheimer did not take his central idea, the importance of co-operation for biological progress, and work it out soberly and sanely with reference to the ascertained facts of science. He would then have given us a valuable book. As it is, this idea is so overgrown with absurdities and irrelevancies that it is scarcely discernible. Until the author eliminates the fantastic and indeed meaningless talk about mind-vitamines, plant-carnivores, symbio-psychism, symbiotic restraint, mnemonic heredity, the necessary degeneration of all carnivorous species, and so on and so forth, the book remains only a subject for melancholy ridicule.

Advance in science comes by laying brick upon brick, not by the sudden erection of fairy palaces.

J. S. HUXLEY.

Famous Chemists. The Men and their Work. By SIR WILLIAM A. TILDEN, F.R.S. (London: Routledge, 12s. 6d. net).

Sir William Tilden is well known as an informed writer on the history of experimental science, especially of his own subject—inorganic chemistry. In this book he has sketched in a simple and interesting way the lives of twenty-one of the most prominent chemists of the past. He has taken pains to make his readers interested in the

lives of these men as they appeared to their friends and fellow-citizens as well as in the particular work in chemistry which they achieved. As the past has produced nearly as many famous chemists as are alive to-day, the author has wisely limited himself to a description of those who have taken part in the development of a great theory, and the theory he has chosen is the Atomic Theory, the joy and glory of modern chemistry.

It is a nice point whether the Greeks or the Hindus were the first to give us the beginnings of the atomic theory. The author, who doubtless hates controversy, has avoided this issue by commencing with the "father of chemistry," Robert Boyle, who lived in the seventeenth century. The evolution of the atomic theory since Boyle has depended on two things: the existence of the crude theory prior to Dalton's (or Higgins') great work, and the development of our knowledge concerning gases. Of pioneers in these fields the author describes Black, Priestley, Cavendish, Scheele, and Lavoisier. He then reaches Dalton, but oddly enough makes no mention of Dalton's rival, William Higgins. Higgins was a failure, Dalton a success. Higgins, moreover, was an objectionable fellow, Dalton a Christian and a gentleman. But it seems now established that Higgins reached essentially the same conclusions as Dalton, and published them four-teen years earlier. He cannot be ignored.

Of the chemists of Dalton's day the author has written of Gay-Lussac, Proust, Berzelius, Davy, and Faraday. These bring us well into the nineteenth century, when the theory went rapidly from strength to strength. Here the author confesses his difficulty in choosing whom to include and whom to leave out. Liebig, the extract-of-meat-merchant, is included more, I think, because Sir William had an accurate and interesting biography of him ready than for any great connection he might have had with the atomic theory. Ramsay, too, might well have been omitted, for although he was a great man and great chemist, his contribution to atomic theory, his work on radio-activity, was at times surprisingly ill-informed and poor. Avogadro, Cannizzaro, Dumas, Frankland, and Williamson are rightly included. In the section on the classification of the elements the author has included Mendeleeff and Crookes, but has given merely a passing mention to Lothar Meyer and Newlands. The German and the Englishman are not so well known as the lion-headed Russian, yet their scientific work is not less important.

These little criticisms are not meant too seriously. The author has a perfect right to choose his men so that their biographies may be made of interest to the general reader. Those he has done are well done. They are accurate and they are interesting. In avoiding dullness he has not allowed himself to fall into a forced breeziness, and he is never slipshod. The book is cordially recommended to readers. Students of chemistry will find it of most value if they use it in conjunction with a technical history of scientific theories, such as Lowry's admirable *Historical Introduction to Chemistry*, published by Macmillan.

A. S. R.

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